

DATA EVALUATION TECHNICAL MEMORANDUM RIVER OPERABLE UNIT

Bradford Island and Bonneville Dam Forebay Cascade Locks, Oregon

July 3, 2014

Prepared for:



U.S. Army Corps of Engineers

Portland District

333 S.W. First Avenue

Portland, Oregon 97208-2946

Prepared by:



111 S.W. Columbia, Suite 1500

Portland, Oregon 97201-5850

25697943

TABLE OF CONTENTS

Section 1.0	INTRODUCTION	1-1
1.1	Background.....	1-1
1.2	Objectives and Organization.....	1-2
Section 2.0	TECHNICAL APPROACH	2-1
2.1	Development of Data Management Rules	2-1
2.1.1	Data Recency	2-1
2.1.2	Proximity	2-1
2.1.3	Sampling Area	2-1
2.2	Updates to Site Database	2-2
2.2.1	Processing Historical Data.....	2-2
2.2.2	Addition of Calculated Sums.....	2-3
2.2.2.1	Aroclor Sums	2-3
2.2.2.2	DDx Sums.....	2-3
2.2.2.3	Summations Using the Kaplan-Meier Method	2-3
2.3	Screening Level Risk Assessment	2-4
2.3.1	Detection Frequency and Comparison of Site Data with Reference Area.....	2-5
2.3.2	Toxicity-based Screening of COIs.....	2-6
2.3.2.1	Ecological and Human Health SLVs	2-6
2.3.2.2	Direct Toxicity and Bioaccumulation.....	2-6
2.3.2.3	Washington Department of Ecology Sediment Criteria	2-7
2.4	Assessment of PCB Congeners and Aroclors.....	2-7
2.5	Kriging and Data Displays.....	2-8
2.5.1	Spatial Interpolation Method	2-8
2.5.2	Development of Variograms.....	2-8
2.5.3	Ordinary Kriging.....	2-9
Section 3.0	RESULTS AND CONCLUSIONS.....	3-1
3.1	Database Update	3-1
3.2	Screening Level Risk Assessments.....	3-1
3.2.1	Detection Frequencies and Comparison of Inorganics to Reference Area UPLs.....	3-1
3.2.2	Identification of COPCs.....	3-2
3.3	Assessment of PCB Congeners and Aroclors.....	3-4
3.4	Discussion of Kriging Data Displays	3-5
Section 4.0	REFERENCES	4-1

TABLE OF CONTENTS

TABLES

- 2-1 Detection Frequency and Upper Prediction Limit Screening of River OU Sediment Data
- 2-2 Human Health Screening of River OU Sediment Data
- 2-3 Ecological Screening of River OU Sediment Data
- 2-4 Summary of Variogram Models

FIGURES

- 1-1 Vicinity Map
- 1-2 Bonneville Dam Complex
- 1-3 Location of Operable Units
- 1-4 River Operable Unit

- 2-1a Bradford Island Site Visualization
- 2-1b Bradford Island Site Visualization - Inset
- 2-2a Linear Regression Model Between Total PCB as Congeners and Total PCB as Aroclors, Using All Available Data (1)
- 2-2b Linear Regression Model Between Total PCB as Congeners and Total PCB as Aroclors, Using All Available Data (2)
- 2-3a Linear Regression Model Between Total PCB as Congeners and Total PCB as Aroclors, Using 2011 Data Only (1)
- 2-3b Linear Regression Model Between Total PCB as Congeners and Total PCB as Aroclors, Using 2011 Data Only (2)

- 3-1 Total Aroclor Concentrations
- 3-2 Total HPAH Concentrations
- 3-3 Total Arsenic Concentrations
- 3-4 Total Mercury Concentrations
- 3-5 Total Nickel Concentrations

TABLE OF CONTENTS

ABBREVIATIONS

%	percent
AOPC	area of potential concern
ATL	acceptable tissue levels
BaP	benzo(a)pyrene
BCF	bioconcentration factor
BHHRA	baseline human health risk assessment
BERA	baseline ecological risk assessment
CENWP	Portland District
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COI	contaminant of interest
COPC	contaminant of potential concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CPEC	contaminant of potential ecological concern
CSL	cleanup screening level
DDD	dichlorodiphenyldichloroethane
DDE	dihlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DETM	Data Evaluation Technical Memorandum
DEQ	(Oregon) Department of Environmental Quality
EMPC	Estimated Maximum Possible Concentration
EPC	exposure point concentration
FS	feasibility study
GRA	general response action
HPAH	high molecular weight polycyclic aromatic hydrocarbon
KM	Kaplan-Meier
MDL	method detection limit
MP	Management Plan
OCF	organochlorine pesticide
OU	operable unit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
RDL	reported detection limit
RI	remedial investigation
RMSE	root mean square error
RSL	Regional Screening Levels
SCO	sediment cleanup objective
SLV	screening level value
SVOC	semivolatile organic compound
TAG	technical advisory group
TCDD	2,3,7,8-tetrachlorodibenzo-para-dioxin
TEF	toxicity equivalence factors
TEQ	toxicity equivalents
TPAH	total polycyclic aromatic hydrocarbons
TPH	total petroleum hydrocarbons
TRV	Toxicity Reference Value

TABLE OF CONTENTS

UCL	upper confidence limit
UPL	upper prediction limits
URS	URS Corporation
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
WDOE	Washington Department of Ecology

1.0 INTRODUCTION

This Data Evaluation Technical Memorandum (DETM) describes the background, technical approach, and results of data evaluation conducted for the River Operable Unit (River OU) at the Bradford Island and Bonneville Dam Forebay (the Site) located in Cascade Locks, Oregon. URS Corporation (URS) prepared this DETM with the United States Army Corps of Engineers (USACE) Portland District (CENWP) in support of the ongoing Feasibility Study (FS) to assure that the appropriate contaminants are considered in the Baseline Risk Assessment and to delineate the extent of contamination in the River OU. Figures 1-1 through 1-3 show the site vicinity, Bonneville Dam Complex, and location of operable units, respectively.

1.1 Background

CENWP completed a Remedial Investigation (RI) and produced the RI Report (URS, 2012) under the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). USACE conducted several debris removals with incidental sediment removal. Most recently, a 2007 CERCLA Non-time Critical Removal action consisted of diver-directed dredging. Human and ecological screening level risk assessments used data collected with a balanced statistical sampling design from the Forebay and Reference Areas (Figure 1-4). These data, referred to as the “RI data set,” included the sediment, surface water, sculpin, crayfish, and clam data that were collected after 2007 (after sediment removals), except for smallmouth bass data, which were collected in 2006 near Goose Island. A “Pre-FS” data collection occurred in 2011, after the Draft RI report was complete, so these data were not included in the final RI report but are included here.

Screening level risk assessments in the RI identified ingestion of polychlorinated biphenyls (PCBs) as the primary risk-driving pathway for both human and ecological receptors for the River OU. The RI Report recommended conducting an FS for the River OU, with further monitoring of PCB concentrations in Forebay fish and shellfish tissue to confirm that PCB tissue concentrations are decreasing over time. Seven additional co-located sediment and clam samples (one location did not result in enough clam tissue for analysis) collected in 2011 met this recommendation. The additional sampling areas were located along the north shore of Bradford Island in the sediment removal areas and in areas suggested by DEQ as the most likely to be influenced by upland sources. Additionally, 23 smallmouth bass samples were collected in 2011 from the Forebay and Reference Area. Twenty of the Forebay and 19 of the Reference Area samples were sent for analysis. Sediment and tissue samples were analyzed for PCBs, organochlorine pesticides, metals, butyltins, and semi-volatile organic compounds (SVOCs), sediment for total organic carbon, and tissue for lipid content. Pre-FS sampling results from the 2011 data indicated that additional chemicals may be chemicals of potential concern (COPCs) for human receptors and chemicals of potential ecological concern (CPECs) for ecological receptors. Therefore, the recommendation in the Final RI Report of moving directly into an FS was changed to recommend completion of baseline human health risk assessment (BHHRA) and baseline ecological risk assessment (BERA) to support the FS.

During the 21 June 2013 TAG meeting, the Oregon Department of Environmental Quality (DEQ) noted that the pre-FS data and data collected outside of sediment removal areas (“pre-RI data”) should be evaluated to identify possible COPCs and CPECs in addition to those identified

in the RI and to assess patterns of contaminant distribution. Such analysis may clarify source areas and support the FS in identifying general response actions (GRAs).

The pre-RI data were not included in the RI screening-level risk assessment because they were not collected using the statistical sampling design that was deemed by USACE to be necessary to support elimination of compounds that were not site related. Following the 21 June 2013 TAG meeting, CENWP decided that the pre-RI and pre-FS data should also be screened to identify what additional COPCs or CPECs need to be carried into the baseline risk assessments.

1.2 Objectives and Organization

In general, this DETM re-evaluates older (pre-RI and pre-FS) data to assess if including the older data would add any constituents as COPCs or CPECs. We also conducted an additional risk screening with the expanded data sets. The screening risk assessments were conducted consistent with the methods in the 2007 RIMP. Data were also displayed in a manner to assist in developing GRAs for the FS.

The DETM is organized as follows:

- **Section 1: Introduction** - Describes the project background and organization
- **Section 2: Technical Approach** - Describes the technical approach and tasks required to complete the data evaluation and prepare the DETM. These tasks include:
 - Development of data management rules and data replacement rules
 - Project database updates
 - Data processing
 - Addition of calculated sums
 - Assessment of the potential to adjust historic sediment Aroclor values
 - Screening level risk assessments
 - Development of data displays
- **Section 3: Results and Conclusions** - Describes the results of the data evaluation including the screening level risk assessments of the pre-RI and pre-FS data

2.0 TECHNICAL APPROACH

This section describes the technical approach to the data evaluation.

2.1 Development of Data Management Rules

URS developed data management rules to apply to the non-RI data (2003 – 2007 “pre-RI” data and 2001 “pre-FS” data) to identify which data qualify for inclusion in the human health and ecological risk assessments. In developing data management rules, URS considered data recency, quality, method of collection (composite versus discrete), and location as described below. Data collected along the north shore of Bradford Island, which were subject to removal actions, were also considered for data replacement.

2.1.1 Data Recency

Sediment data collected from areas where equipment and debris were removed in 2000 and 2002 were not included in the data evaluation because the equipment and associated sediment were removed (see *In-Water Investigation Report, Bradford Island Landfill, Cascade Locks, Oregon*, URS, 2002a and the *Technical Memorandum, In-Water Removal Work, Bradford Island Landfill, Cascade Locks, Oregon*, URS, 2002b). Data collected from 2003 through 2011 were retained for the data evaluation.

2.1.2 Proximity

Samples collected in 2008 and 2011, and after the 2007 diver-assisted dredging, were composited over a sampling area. The composite grid consisted of cells of 50 feet by 50 feet, although in some cases the grid areas were expanded to 75 feet by 75 feet to obtain adequate sample volume. These newer post-removal (RI and Pre-FS data) samples provide a more recent and more representative estimation of analyte concentrations in the respective sampling areas, as compared to the pre-removal point-samples (i.e., a grab sample collected from one location).

Pre-removal grab samples were not included in the data evaluation dataset if they were contained within the area of a composite post-removal sample and if the analyte in the grab sample was included in the composite sample. If an analyte was included in the pre-removal grab sample but not in the post-removal grab sample, then that analyte was retained in the data set.

2.1.3 Sampling Area

River OU data from 2003 through 2011 represent the following sampling areas:

- Forebay
 - The Forebay Area as considered in the 2012 Final RI (URS, 2012)
 - Samples collected in 2011 were also collected from this area.
- Forebay – Eagle Creek
 - Samples collected on the alluvial fan of Eagle Creek

- These were not considered with the “Forebay” data group in the Final RI (URS, 2012)
- Forebay – Goose Island
 - Samples collected nearshore to Goose Island
 - These were not considered with the “Forebay” data group in the Final RI (URS, 2012)
- Reference – River Mile 147
 - Reference area for the Stage 1 and Stage 2 Sediment Investigations (URS, 2004)
 - Upstream of the Forebay Area considered in the Final RI (URS, 2012)
- Reference – River Mile 150
 - Reference Area for the Final RI (URS, 2012)
- Downstream
 - Samples collected immediately downstream of Bonneville Dam

Both RI and Non-RI sample locations were mapped to evaluate the Non-RI sample locations relative to the RI sampling area (Figures 2-1a and 2-1b). Non-RI data were grouped as in the RI, using the mapped RI data as a guide. Only samples representing data in the “Forebay” sampling area, as described in the 2012 RI, were considered as “Forebay” samples for the data evaluation. Data for Eagle Creek and Goose Island will be retained for inclusion in the BHHRA and BERA.

2.2 Updates to Site Database

Data that qualified for inclusion in the human health and ecological risk assessments according to the data management rules described in Section 2.1 were added to the RI database. Merging non-RI and RI data into a single data set required the non-RI data set to be treated in the same manner as the RI data set. Section 5.1 of the RI Report (URS, 2012) describes data handling for the RI data. Additional updates to the database are described in the sections below.

2.2.1 Processing Historical Data

Results of field duplicates were averaged with corresponding primary sample values to create a single value, as long as the analytes were detected in both the primary and field duplicate samples. If the analyte was detected in only one of the pair, the detected value was kept unaltered, and the method detection limit (MDL) associated with this value was considered as the MDL of the result. If the analyte was not detected in either sample, the lowest MDL of the pair was used. In all cases, the selected MDL (after data quality review) was used. For some historical data where only a method reporting limit (MRL) was available, the MRL was used instead of the MDL. This procedure follows DEQ’s guidance for the treatment of data for primary samples and duplicates (DEQ, 2009b). This process was completed for the non-RI data considered for the data evaluation

2.2.2 Addition of Calculated Sums

2.2.2.1 Aroclor Sums

As described in the RI, the summation of Aroclors depended on whether a particular analyte Aroclor had been detected in at least one of the samples from the same media in a given area (in the present case, Forebay area sediment). If not, that Aroclor was not considered in the Aroclor summation for each sample. Previously calculated Aroclor summations for the RI data were not modified. The 2011 pre-FS sediment samples were considered separately from the pre-RI data collected between 2003 and 2007 (pre-removal). The following Aroclors were detected:

- Only Aroclor 1254 was detected in pre-FS samples.
- Aroclors 1248, 1254, and 1260 were detected in pre-RI samples.

The lab reported two quantitation limits, the MDL and MRL, for Aroclor data. To create sums in the database which reflect the use of either of these quantitation limits, two types of Aroclor sums for each sample were calculated (based on either the MDL or the MRL). Among the Aroclors considered for summation in the two sets of data mentioned above, if a result was non-detect, half the quantitation limit (MDL for MDL-based sums, MRL for MRL-based sums) was used in the summation.

2.2.2.2 DDx Sums

Summation of dichlorodiphenyldichloroethane (DDD), dichlorodiphenyldichloroethylene (DDE), and dichlorodiphenyltrichloroethane (DDT) analytes (Total DDx) was not done for River OU data in the RI report. Therefore, Total DDx was calculated for all samples in the data set considered in the DETM. Total DDx was summed based on the MDL and MRL of non-detects, creating two types of DDx sums for each sample. Non-detects were included as the full quantitation limit (MDL or MRL) in Total DDx summations for each sample.

2.2.2.3 Summations Using the Kaplan-Meier Method

Data summations were done using the Kaplan-Meier (KM) method suggested by Helsel (2009). The KM approach for the Bradford Island site is documented in *Modified Approach for Calculating Total Concentrations of PCBs and PAHs Technical Memorandum* (URS, 2010). The method applies to parameters that require a summation or weighted-summation of a number of individual constituents, except for Aroclors, which are treated as described above. This same data calculation approach was used for RI data set, and was reviewed by Oregon DEQ at that time. The approach addresses the issue of summing a data set containing non-detects (i.e., censored values).

The KM method was applied to the following parameters:

- Total PCBs (as congeners)
- Total polycyclic aromatic hydrocarbons (PAHs)
- PCB toxicity equivalents ((TEQs) (Bird, Fish, Mammal) and
- Carcinogenic PAH (cPAH) benzo(a)pyrene equivalents (BaP EQs)

The KM method is a non-parametric statistical method and does not require assumptions of normality (Kaplan and Meier, 1958). It is currently the recommended method used in United States Environmental Protection Agency's (USEPA's) ProUCL software for calculating the 95 percent (%) UCL for data sets with one or more censored results (Singh et al., 2013a, 2013b). In the application of summing a group of related compounds, the KM mean is estimated from a set of data (consisting of detected and non-detected values) coming from a given sample, and this KM mean is then multiplied by the number of compounds ($\text{mean} \times n$) to compute the sum for the sample.

In this calculation process, the KM method and Efron's bias correction method (as encoded in the ProUCL software) were used to sum the total PCB and PAH concentrations and to calculate the weighted sum of total PCB TEQs and cPAH BaP EQs. Efron's bias correction treats the minimum censored result as a detection (USEPA, 2010). This bias correction has been implemented by the latest version of the ProUCL software (version 5.0.00). The KM method is used whenever it is feasible with the ProUCL software (i.e., when there are five or more components to the sum and at least two detected results [three coded-detected results if Efron's bias correction is used]) (USEPA 2013). To safeguard against a potential biased-high estimate of the KM mean, if the summation results in a total concentration greater than a simple summation (or weighted-summation) of detected concentrations and full censoring concentrations (MDL, MRL, or reported detection limit [RDL]) of the non-detected data, the simple sum will establish an upper bound of the total concentration.

Total PCBs (as Congeners). Total concentrations were calculated using the KM method, considering undetected data at the RDL. For the 2011 pre-FS congeners data, as used for the prior RI data, the estimated maximum possible concentration (EMPC-qualified) values were treated as detected concentrations. The resulting total concentration was capped by the simple sum of detected concentrations, EMPC-qualified concentrations, and RDLs for undetected congeners.

Total PAHs. Total concentrations were calculated for low-molecular weight PAHs (LPAHs), high-molecular weight PAHs (HPAHs), and total PAHs (tPAHs). No individual PAHs were excluded from the sums. The sums were calculated twice: once using the MDL as the censoring value for non-detects, and once using the MRL as the censoring value for non-detects. Whenever a minimum of five PAHs were included in a sum, and at least two PAHs were detected, the sum was calculated using the KM method, capped by the simple sum with undetected results set at the MDL (or MRL). When these requirements were not met, the sum was calculated as the simple sum with undetected results set at the MDL (or MRL).

Total PCB TEQs (Bird, Fish, Mammal) and cPAH BaP EQs. The same process for total PCBs (as congeners) and total PAHs was used, except that toxicity equivalence factors (TEFs) were incorporated as weights in the summation process, resulting in sum of equivalents.

2.3 Screening Level Risk Assessment

The purpose of this screening level risk assessment is to identify COPCs and CPECs in sediment that should be carried into the BHHRA and BERA in addition to those COPCs/CPECs identified in the Final RI (URS, 2012). Contaminants of interest (COIs) are defined as chemicals that are

present or may be present at a site that have not been screened against any criteria (DEQ 2001, 2010). For the purposes of risk assessments, COIs may be further evaluated based on detection frequency, comparison with background levels, and risk-based screening. COIs that exceed the criteria are retained as COPCs and/or CPECs and may be recommended for risk management, and COIs do not exceed the criteria are dropped from further consideration.

The following steps follow DEQ's general screening criteria used to identify COPCs/CPECs, and were utilized in the RI screening level assessments. COIs that exceed the criteria are retained as COPCs/CPECs (DEQ, 2001, 2010), but COIs that meet any of these following criteria need not be retained:

1. COIs detected at less than a 5% detection frequency, assuming adequate nature and extent delineation, acceptable reporting limits (i.e., below benchmarks protective of ecological receptors), and are not site-related per the Final RI response to comments (Appendix P of URS, 2012);
2. Inorganic COIs present at concentrations below naturally occurring levels that are either site-specific or derived from regional concentrations;
3. COIs that are below toxicity-based criteria established for human or ecological receptors based on exposure to individual COIs, as well as cumulative exposure to COIs.

Although these criteria may be met, a COI may be retained as a potential COPC/CPEC under the following circumstances:

1. COIs that are detected at least once, are bioaccumulative, and lack a bioaccumulation-based screening level value (SLV), require further investigation for their potential to impact human health and upper-trophic-level ecological receptors through the dietary pathway.
2. COIs that lack direct ecological toxicity-based criteria (i.e., invertebrate SLVs) require further consideration, such as a qualitative assessment of risk.

All COPCs/CPECs in sediment identified based on the above criteria were retained for further evaluation in the River OU's BHHRA and BERA.

2.3.1 Detection Frequency and Comparison of Site Data with Reference Area

The use of the 5% detection frequency criterion assumes that site characterization is adequate and representative (given a sample size ≥ 20). In accordance with DEQ and USEPA guidance and consistent with the methodology in the Final RI (URS, 2012), those COIs with a detection frequency less than 5% are typically not retained as COPCs or CPECs for further consideration. However, based on the Final RI response to comments (Appendix P of URS, 2012), COIs detected less than 5% were retained for future evaluation in the River OU BHHRA and BERA if they are potentially site-related.

The objective of comparing site data to the reference area is to determine which inorganic constituents have elevated concentrations in site media relative to background, and therefore may

be attributable to the site, and which have concentrations that are indistinguishable from background and are likely from sources other than the site. Those inorganic constituents with maximum detected concentrations less than the Reference Area 95% upper prediction limits (UPLs) were not retained for future evaluation in the River OU BHHRA and BERA.¹

Table 2-1 lists the detection frequencies for COIs detected in site samples and compares the maximum detected concentrations of an inorganic constituent to the Reference Area UPLs.

2.3.2 Toxicity-based Screening of COIs

The third step of the COPC and CPEC identification process is to compare COI concentrations to risk-based screening concentrations that are specific to the media, receptors, and pathways that are relevant to the site. The potential for bioaccumulation and the availability of dietary-based SLVs are two additional qualitative elements evaluated in the identification of COPCs and CPECs. Tables 2-2 and 2-3 present the human health and ecological risk-based screening tables, respectively, and are discussed in further detail in Section 3.2.

2.3.2.1 Ecological and Human Health SLVs

SLVs were selected for human and ecological receptors, based on the hierarchy of sources presented in the Final RI (Appendix J of URS, 2012, Tables J-4e and J-5c). SLVs based on similar chemicals (“surrogate” chemicals) were applied to COIs without SLVs, when determined appropriate, and additional SLVs were added based on the established hierarchy for additional COIs not previously evaluated in the Final RI (e.g., pesticides and dioxin/furans). Site-specific reference concentrations were used to establish SLVs for inorganic constituents only, which is similar to the approach used in DEQ’s guidance (2007). As discussed in the Final RI (URS, 2012), the SLV selection hierarchy was developed based on discussions with the USACE and DEQ (URS, 2010a, URS, 2010b, 2010c).

2.3.2.2 Direct Toxicity and Bioaccumulation

Consistent with the Final RI (URS, 2012), direct toxicity for the benthic community exposed to COIs in sediment and exposure of human receptors and upper-trophic level ecological receptors to bioaccumulative COIs originating from sediment was evaluated.

Bioaccumulation is a phenomenon in which environmental concentrations of chemicals accumulate in biological adipose and organ tissues. Bioaccumulation occurs as living organisms retain and concentrate chemicals both directly from their surrounding environment (i.e., from soil or water) and indirectly from media that transfer chemicals into dietary components, such as plant or animal tissues. Biomagnification is a form of bioaccumulation in which the concentration of a chemical in a higher trophic level organism (e.g., bird, mammal, reptile, or human) is greater than the concentration in the food that this organism consumes.

¹ The BHHRA, BERA, and FS will further evaluate whether detected constituents are site related and subject to the FS by other statistical means under the ARARs.

Bioaccumulation and biomagnification are of primary interest in risk assessments because of the potential for chemical transfer through the food web, as people and top-level predatory species consume food that may have high tissue residues of bioaccumulative chemicals. Thus, even though the people or predatory biota are not directly exposed to chemicals in soil or water, they may still be adversely affected because of their indirect exposure to these chemicals through consumption of fish, shellfish, or other food items.

Bioaccumulative compounds were identified as outlined in the Final RI (Appendix J, Table J-7, URS, 2012) based on the following:

- Nonpolar organic compounds with octanol-water partition coefficient ($\log K_{ow}$) > 3.5 (with optimum range between 3.5 and 5.5; Suter, 1993);
- Inorganic compounds with a bioconcentration factor (BCF) > 300

Bioaccumulative COIs without bioaccumulation-based SLVs are retained as a potential COPC/CPEC for future evaluation in the River OU BHHRA and BERA.

2.3.2.3 Washington Department of Ecology Sediment Criteria

The Sediment Management Standards developed by the Washington Department of Ecology (Ecology) promote a two-tiered decision-making framework to protect the functions and integrity of the benthic community (Ecology, 2013a). Two types of sediment criteria are presented in the WDOE's most recent *Sediment Cleanup Users Manual II, Guidance for Implementing the Cleanup Provisions of the Sediment Management Standards* (Ecology, 2013b): sediment cleanup objectives (SCOs) and cleanup screening levels (CSLs). The SCOs are lower-bound levels predicted to have no adverse effects on the macroinvertebrate community from direct toxicity. The CSLs are upper-bound criteria that predict minor adverse effects on the macroinvertebrate community. Both types of criteria are specifically applicable to direct toxicity to benthos exposed to sediment and do not account for effects related to bioaccumulation in the aquatic food web. The WDOE criteria are presented in Table 2-3 (screening level RA for ecological receptors) for informational purposes, but were not specifically used to screen the site data. Ecology's criteria may be considered in the future for the River OU during the BERA and development of risk-based preliminary remediation goals.

2.4 Assessment of PCB Congeners and Aroclors

PCB congeners and Aroclor results were assessed to determine whether there was a sufficient basis for adjusting historical sediment Aroclor values to correct for differential quantitation by the two analytical methods used to measure PCBs in site samples: EPA Method 8082 for Aroclors and EPA Method 1668 for congeners. If there were a functional, quantitative relationship between the concentration values, then an equation may be derived that would allow prediction of PCB concentrations as congeners from historic Aroclor data. However, if there were no reliable functional relationship, both sets of data would be retained and carried through the risk assessment processes.

The relationship between total PCBs as Aroclors and total PCBs as congeners was tested statistically by linear regression. Because the summation for total PCBs was governed by the methods described in Section 2.2.2, and these calculated summed values were subsequently used in risk assessments, the summed values used in the regression model were based on the outcomes from Section 2.2.2.

All available samples in the database, with both total PCBs as Aroclors and total PCBs as congeners results, were used in this evaluation. A subset of this data set, samples collected in 2011, was also examined separately. The regression plots and associated statistics are shown in Figures 2-2a, 2-2b, 2-3a and 2-3b. An anomalously high value, collected from location P113, was excluded as an input to the regression model, as it may unduly influence the regression statistics and fit. The results of this evaluation are discussed in Section 3.3.

2.5 Kriging and Data Displays

2.5.1 Spatial Interpolation Method

URS used geostatistical kriging to map the extent of concentrations of select COPCs/CPECs near the north shore of Bradford Island. Kriging is a method of spatial interpolation that allows estimation of concentrations at unsampled locations using concentrations at sampled locations and a model of spatial continuity. In estimating concentrations, kriging also quantifies the uncertainty in the estimated values; namely, the kriged standard deviation of the estimated value. The kriged standard deviation can be used to define error bounds on an estimated value.

Kriging requires a model of spatial continuity of the concentration values. Such a model is called a variogram. A variogram is a plot of the average squared differences of paired sample measurements as a function of the distance (and possibly of the direction) between samples. The greater the variability in the sample measurements separated by a certain distance, the larger is the variogram value plotted on the y-axis at that distance. A variogram provides a tool for quantifying the commonly observed relationship that samples close together tend to have more similar (correlated) values than samples far apart. The pattern of spatial correlation exhibited in a variogram helps to understand how homogeneous or heterogeneous the field of measurements is. This, in turn, has an influence on how reliable estimates of concentrations would be averaged over different scales.

For this spatial analysis, the following five key analytes (primary risk drivers with adequate detections to perform spatial analysis) were evaluated: arsenic, mercury, nickel, total HPAHs, and total PCB as Aroclors.

2.5.2 Development of Variograms

The key components of a variogram are the sill, range of correlation, and nugget. The basic premise of a variogram is that measurements of a spatially varying property (such as chemical concentrations) that are close to each other are generally correlated. This means that the y-value on a variogram (i.e., the average squared difference) would be smaller at a short separation distance between samples and this value would increase as the separation distance increases. However, beyond a certain distance, measurements are not correlated, and the variogram reaches

a plateau. This plateau is called the sill of a variogram and the separation distance at which the variogram reaches this plateau is called the range of correlation.

A nugget in a variogram is a measure of short-scale spatial variability, including random measurement error. Discrete points for a variogram plot are calculated using available sample data. A “best-fit” line is then drawn to fit these points. The nugget is estimated by the intercept of this line on the y-axis. If co-located field samples taken next to each other show very different measurement values, this would suggest significant short-scale variability and would show as a large nugget in the variogram. The nugget, expressed as a fraction of the sill, defines the portion of the sill (i.e., the total spatial variability) attributed to short-scale variability. The larger the nugget as a fraction of the sill, the greater is the variability in closely-spaced measurements.

A larger range of correlation with a small relative nugget would suggest spatially a more continuous field of measurements. On the other hand, a smaller range of correlation and a large nugget would suggest a heterogeneous field of measurements.

Because different directions of the Site may have different types or scales of spatial continuity, directional variograms were developed. For this site, the major axis is defined as east-west (i.e., 90 degree), and the minor axis is defined as north-south (0 degree). Since the range of correlation appeared to be longer for the east-west direction, geometric anisotropy, for which the range changes with direction, while the sill remains constant, was incorporated in the variogram modeling.

Table 2-4 summarizes the key variogram parameters for the five analytes. For the subject data, the nugget effect for total HPAHs and total PCB as Aroclors was relatively high, which means that there was likely high short-scale variability for these analytes.

2.5.3 Ordinary Kriging

The ordinary kriging method of geostatistics was used to estimate concentrations of each of the five selected analytes (arsenic, mercury, nickel, total HPAHs, and total PCB as Aroclors) at unsampled locations near the north shore of Bradford Island. Ordinary kriging estimates both a concentration and the standard deviation of that estimate at each specified unsampled location. For purposes of kriging, a grid of 10 feet by 10 feet cells was defined over the study area, and kriging estimates were obtained at each of the grid nodes.

Other necessary kriging inputs include search ellipsoid distances and angles (i.e., how far and which direction to search for hard data to include in the spatial interpolation), and the minimum and maximum number of conditioning data to be retained (i.e., how many hard data points to be included in the spatial interpolation process). For this evaluation, the search ellipsoid distances were typically twice the distance of the range of correlation, and the search ellipsoid angles were the same as those defined in the variogram model. The minimum and maximum number of conditioning data were set to be from 2 to 15, and if there were less than two hard data points available in the search ellipsoid, the kriging estimation was not performed at that cell.

3.0 RESULTS AND CONCLUSIONS

The following sections presents the results of the data evaluation.

3.1 Database Update

The project Access database was updated in accordance with procedures outlined in Sections 2.1 and 2.2. An electronic copy of the database will be provided to the USACE.

3.2 Screening Level Risk Assessments

This section presents the findings of the screening level risk assessments conducted to identify COPCs and CPECs through an evaluation of 2003-2007 pre-RI data and the 2011 pre-FS sediment data, which were not included in the Final RI (URS, 2012). The methods for the screening level RAs were described in Section 2.3 and include the following three steps: 1) evaluation of detection frequency (i.e., identify COIs detected in 5% of samples or less); 2) comparison of maximum detected concentrations of inorganic COIs to Reference Area UPLs; and 3) comparison of site concentrations to risk-based screening levels protective of human and ecological receptors.

3.2.1 Detection Frequencies and Comparison of Inorganics to Reference Area UPLs

Table 2-1 lists the detection frequencies for COIs in site samples and compares the maximum detected concentrations of inorganic COIs to the Reference Area UPLs. In the absence of a site-specific UPL for selenium, the regional background level in sediment was used (DEQ, 2007). Except for selenium and silver, detection frequencies for inorganic COIs were greater than 5%. Of the 18 inorganic COIs analyzed in sediment, 12 were detected above the Reference Area UPLs. COIs with maximum detected concentration greater than the Reference Area UPL or for which no site-specific or regional sediment background level is available were retained for the risk-based screening (Tables 2-2 and 2-3).

Of the various PCBs analyzed in site sediment samples, the following have detection frequencies greater than 5%:

- Aroclor 1254
- Total PCBs as Aroclors (both MDL and MRL-based)
- Total PCBs as 209 congeners

Only the 12 dioxin-like PCB congeners from the 209 total congeners are listed in Table 2-1. The dioxin-like congener, PCB 169, had a detection frequency of 4% but was retained for the risk-based screening along with the 11 other dioxin-like PCB congeners, which did have detection frequencies greater than 5%. Aroclors 1248 and 1260 have detection frequencies less than 5% but were also retained for the risk-based screening as individual Aroclors and as Total PCBs as Aroclors based on their potential for being site-related.

Only two butyltins (dibutyltin dichloride and tributyltin chloride) were detected, and although both had detection frequencies less than 5%, they were retained for the risk-based screening

based on their potential to be site-related. Butyltins have been detected in soils of the Landfill and Sandblast Areas of Potential Concern (AOPCs) and are currently being evaluated in the Upland OU baseline risk assessments. Similarly, all detected SVOCs (including PAHs) and organochlorine pesticides (OCPs) were retained for the risk-based screening, even though several have detection frequencies less than 5%, due to their known presence in soils from the Landfill and Sandblast Area AOPCs.

The only detected dioxin-furan, OCDD, had a detection frequency greater than 5% and was also retained for the risk-based screening.

Total petroleum hydrocarbons (TPH) as Diesel Range Organics and Residual Range Organics were detected at low concentrations in sediment and were not retained for the risk-based screening because petroleum is not a CERCLA contaminant and because there are no reliable SLVs for petroleum mixtures. However, TPH was evaluated through indicator chemicals (SVOCs and PAHs) in the risk-based screening.

3.2.2 Identification of COPCs

Table 2-2 lists the COPCs identified through the risk-based screening for human health based on bioaccumulation concerns. All COIs for which the 95% upper confidence limit (UCL) (or maximum detected concentration for cases where the 95% UCL was not calculated) in sediment was greater than the bioaccumulation SLVs for the recreational angler or subsistence fisher were identified as COPCs. Potentially bioaccumulative COIs, as defined in the Final RI (URS, 2012), lacking bioaccumulation SLVs were also identified as COPCs. All sediment COPCs will be retained for the BHHRA, where their corresponding tissue data for crayfish and bass will be evaluated, as the site-specific tissue data are the best indicator of whether or not that particular COPC is bioaccumulating at the site.

Direct exposure to sediments for waders is also affected by the 2011 sediment data since the waders and potential fishing-net recreationists are assumed to be exposed to shallow sediments near the mouth of Eagle Creek (RI Management Plan (MP), URS, 2007, RI Report, 2012) as well as along the shorelines (URS, 2014). Since there are no readily available SLVs for direct contact with sediments, the COPCs for this scenario will include all COIs detected in shoreline sediments (taking comparison with reference UPLs and detection frequency into consideration).

In the BHHRA, the 2008 crayfish data and 2006 and 2011 bass tissue data will be assessed for the sediment COPCs identified in Table 2-2. If the site-specific tissue data exceed DEQ's acceptable tissue levels (ATLs) for recreational anglers or subsistence fishers, these tissue COPCs may be carried into the quantitative risk calculations conducted in the BHHRA. If the site-specific tissue data for particular sediment COPC do not exceed the fish consumption ATLs, this COPC will be discussed qualitatively in the uncertainty assessment of the BHHRA. COPCs lacking bioaccumulation SLVs and ATLs may also be retained for the quantitative risk calculations conducted in the BHHRA.

Consistent with screening-level risk assessments in the Final RI (URS, 2012), the concentrations of bass tissue COPCs detected in 2011 will be compared to those detected in 2006, which were evaluated in the Final RI (URS, 2012). If the 2011 bass concentrations are equivalent to or lower

than the 2006 bass concentrations, the findings of the screening-level HHRA for that particular COPC may still be relevant.

The following sediment COPCs were identified in Table 2-2 for the bioaccumulation pathway:

- Aroclors 1248, 1254, and 1260
- Total PCBs as Aroclors
- Total PCBs as 209 congeners
- 12 individual dioxin-like PCB congeners
- PCB TEQ
- arsenic
- lead
- manganese
- zinc
- tributyltin chloride
- nine OCPs
- five SVOCs

These sediment COPCs may be considered for development of preliminary remediation goals (PRGs), based on the results and findings of the forward risk calculations in the BHHRA for the subsistence and recreational fish consumption scenarios.

3.2.3 Identification of CPECs

Table 2-3 lists the CPECs identified through the risk-based screening for ecological receptors. All COIs for which the maximum detected concentration in sediment was greater than the direct toxicity SLVs for the freshwater benthic community were retained as CPECs for the BERA. The CPECs lacking a direct toxicity SLV will be retained for qualitative evaluation in the uncertainty assessment in the BERA.

The following sediment CPECs were identified in Table 2-3 based on the direct toxicity screening for the benthic community:

- Aroclors 1248, 1254, and 1260
- Total PCBs as Aroclors
- Total PCBs as 209 congeners
- 11 metals
- two tributyltins
- five OCPs
- ten HPAHs (plus Total HPAHs)
- two LPAHs (plus Total LPAHs)
- four SVOCs

All COIs for which the 95% UCL (or maximum detected when the UCL was not calculated) in sediment was greater than the bioaccumulation SLVs for freshwater fish and aquatic-dependent birds and mammals were identified as CPECs. Potentially bioaccumulative COIs, as defined in

the Final RI (URS, 2012), lacking bioaccumulation SLVs were also identified as CPECs. All sediment CPECs will be retained for the BERA, where their corresponding tissue data for clams, crayfish, sculpin, and bass will be evaluated, as the site-specific tissue data are the best indicator of whether or not that particular CPEC is bioaccumulating at the site.

In the BERA, the following tissue data will be assessed for the sediment CPECs identified in Table 2-3: 2008 and 2011 clam tissue; 2008 crayfish and sculpin tissue; and 2006 and 2011 bass tissue. If the site-specific tissue data indicate an exceedance of DEQ's ATLs for fish and wildlife, these CPECs may be carried into the quantitative risk calculations conducted in the BERA. If the site-specific tissue data for particular sediment CPEC do not exceed the ATLs, this CPEC will be discussed qualitatively in the uncertainty assessment of the BERA. CPECs lacking bioaccumulation SLVs and ATLs may also be retained for the quantitative risk calculations conducted in the BERA.

To maximize use of the work that was performed in the screening-level RAs included in the Final RI and to avoid duplication of those efforts, the concentrations of clam and bass tissue CPECs detected in 2011 will be compared to those detected in 2008 (clams) and 2006 (bass), which were evaluated in the Final RI. If the 2011 tissue concentrations are equivalent to or lower than the 2006 and 2008 concentrations, the findings of the screening-level ERA for that particular CPEC may still be relevant.

The following sediment CPECs were identified in Table 2-3 based on the bioaccumulation screening for fish and wildlife:

- Aroclors 1248, 1254, and 1260
- Total PCBs as Aroclors
- Total PCBs as 209 congeners
- eight individual dioxin-like PCB congeners,
- PCB TEQs
- Arsenic
- Lead
- Manganese
- zinc
- two tributyltins
- 10 OCPs
- five SVOCs

3.3 Assessment of PCB Congeners and Aroclors

PCB congeners and Aroclor results were assessed to determine whether there was a sufficient basis for adjusting historical sediment Aroclor values to correct for differential quantitation by the two analytical methods used to measure PCBs in site samples: EPA Method 8082 for Aroclors and EPA Method 1668 for congeners.

As shown in Figures 2-2a, 2-2b, 2-3a and 2-3b, the various regression models appeared to show a positive correlation between total PCBs as Aroclors and total PCBs as congeners, with a correlation of determination (R^2) ranging from 0.68 to 0.95. (The R^2 of 0.95 from one of the

regression models was likely due to excessive influence from the high value, as well as small sample size.) However, the root mean square error (*RMSE*), a measure of the differences between values predicted by a model and the values actually observed, was fairly large. The *RMSE* represents the sample standard deviation of the differences between predicted values and observed values, and a large *RMSE* means that the prediction is not *accurate*. For instance, for the model using all available data but without the high value (i.e., the second model of Figure 2-2b), the *RMSE* was almost twice as high as the mean of response, meaning that the average prediction would have an error of plus or minus 200%.

Since the regression model did not result in a reasonably accurate and reliable functional relationship, both sets of PCB data were recommended to be retained and carried through the risk assessment processes.

3.4 Discussion of Kriging Data Displays

The ordinary kriging method of geostatistics was used to estimate concentrations of each of the five selected analytes (arsenic, mercury, nickel, total HPAHs, and total PCB as Aroclors) at unsampled locations near the north shore of Bradford Island and develop data displays for each of the analytes.

The data displays are presented as Figures 3-1 through 3-5. The purpose of the data displays is one tool to guide the selection of GRAs. The color scheme approximates SLVs that will be considered as PRGs. The color ramp generally changes from green to yellow at the SLV. For nickel, the SLV was set by background.

The FS will assess areas and volumes for evaluation of cleanup alternatives. For purposes of this DETM, the footprint of the COCs generally overlap. For example, areas with elevated PCBs including 2007 removal areas, sandblast area sewer out fall, and the east tip of Bradford Island, also had elevated detections of other COCs, include PAHs and metals. The overlap of the area and the implications for remedy selection will be more thoroughly developed in the FS.

4.0 REFERENCES

- DEQ. 2001. Guidance for Ecological Risk Assessment: Levels I, II, III, IV. Waste Management and Cleanup Division. Final. April 1998. Updated December 2001.
- DEQ. 2007. Guidance for Assessing Bioaccumulative Chemicals of Concern in Sediment. Final. April
- DEQ. 2009. Oregon Administrative Rule 340-041. Chapter 340, Division 41: Water Quality Standards: Beneficial Uses, Policies, and Criteria for Oregon. Tables 33A, 33B, and 33C. November.
- DEQ. 2010a. Human Health Risk Assessment Guidance. Final. October.
- DEQ. 2010b. Guidance for Assessing and Remediating Vapor Intrusion in Buildings. Final. March 25.
- Helsel, D.R. 2009. "Summing Nondetects: Incorporating Low-Level Contaminants in Risk Assessment." Integrated Environmental Assessment and Management. Volume 6, Number 3: 361-366.
- Kaplan, E.L., and P. Meier. 1958. "Nonparametric Estimator from Incomplete Observations." Journal of the American Statistical Association. Volume 53: 457-481.
- Singh, A. and R. Maichle. 2013a. *ProUCL Version 5.0.00 User Guide*. Office of Research and Development, U.S. Environmental Protection Agency, Report No. EPA/600/R-07/041.
- Singh, A. and A.K. Singh. 2013b. *ProUCL Version 5.0.00 Technical Guide*. Office of Research and Development, U.S. Environmental Protection Agency, Report No. EPA/600/R-07/041.
- Suter, G. 1993. Ecological Risk Assessment. Boca Raton, FL. Lewis Publishers.
- URS. 2002a. In-Water Investigation Report, Bradford Island Landfill, Cascade Locks, Oregon
- URS. 2002b. Technical Memorandum, In-Water Removal Work, Bradford Island Landfill, Cascade Locks, Oregon
- URS. 2007. Remedial Investigation/Feasibility Study (RI/FS) Management Plan (MP), Bradford Island, Bonneville Lock and Dam Project, Cascade Locks, Oregon. September.
- URS. 2010. Modified Approach for Calculating Total Concentrations of PCBs and PAHs Technical Memorandum
- URS. 2012. Upland and River Operable Units Remedial Investigation Report. Bradford Island, Bonneville Dam Forebay, Cascade Locks, Oregon. June.
- URS 2014. Risk Assessment Work Plan for Upland OU. Technical Memorandum. March

USEPA. 2010. "Calculation of Total Dioxin TEQs with Nondetect and Rejected Congeners." Deana Crumbing, U.S. Environmental Protection Agency. Draft. September 8.

USEPA. 2013. ProUCL Version 5.0.00 (Software). Retrieved from <http://www.epa.gov/osp/hstl/tsc/software.htm>. September.

WDOE. 2013a. Sediment Management Standards, Chapter 173-204 Washington Administrative Code, Publication no. 13-09-055. Revised February 2013.

WDOE. 2013b. Sediment Cleanup Users Manual II, Guidance for Implementing the Cleanup Provisions of the Sediment Management Standards, Publication no. 12-09-057. December

TABLES

Table 2-1
Detection Frequency and Upper Prediction Limit Screening of River OU Sediment Data

metals only
[max] > UPL

Rate > 5%

Analyte Group	IUPAC Number	Analyte	Units	Minimum Detected	Maximum Detected	Results Enumeration				Site-Specific Reference Metal UPLs
						Total	Detect	Non-Detect	Detection Rate	
PCB Aroclors		Aroclor 1016	ug/kg	-	-	99	0	99	0%	-
PCB Aroclors		Aroclor 1221	ug/kg	-	-	99	0	99	0%	-
PCB Aroclors		Aroclor 1232	ug/kg	-	-	99	0	99	0%	-
PCB Aroclors		Aroclor 1242	ug/kg	-	-	99	0	99	0%	-
PCB Aroclors		Aroclor 1248	ug/kg	140	140	99	1	98	1%	-
PCB Aroclors		Aroclor 1254	ug/kg	1.00	22000	99	70	29	71%	-
PCB Aroclors		Aroclor 1260	ug/kg	5.80	140	99	3	96	3%	-
PCB Aroclors		Aroclor 1262	ug/kg	-	-	29	0	29	0%	-
PCB Aroclors		Aroclor 1268	ug/kg	-	-	29	0	29	0%	-
PCB Aroclors		Total PCBs as Aroclors (MDL-based)	ug/kg	1.45	22191	99	71	28	72%	-
PCB Aroclors		Total PCBs as Aroclors (MRL-based)	ug/kg	2.10	22560	99	71	28	72%	-
PCB Congeners		Total PCBs as Congeners (KM-based, capped)	ug/kg	0.0611	4312	27	27	0	100%	-
PCB Congeners ²	77	3,3',4,4'-Tetrachlorobiphenyl	ug/kg	2.09E-04	0.530	27	26	1	96%	-
PCB Congeners ²	81	3,4,4',5-Tetrachlorobiphenyl	ug/kg	1.03E-04	0.0320	27	6	21	22%	-
PCB Congeners ²	105	2,3,3',4,4'-Pentachlorobiphenyl	ug/kg	0.00130	98.4	27	27	0	100%	-
PCB Congeners ²	114	2,3,4,4',5-Pentachlorobiphenyl	ug/kg	5.80E-05	5.34	27	27	0	100%	-
PCB Congeners ²	118	2,3',4,4',5-Pentachlorobiphenyl	ug/kg	0.00271	233	26	26	0	100%	-
PCB Congeners ²	123	2,3',4,4',5'-Pentachlorobiphenyl	ug/kg	6.40E-05	3.13	27	24	3	89%	-
PCB Congeners ²	126	3,3',4,4',5-Pentachlorobiphenyl	ug/kg	1.23E-04	2.96E-04	27	11	16	41%	-
PCB Congeners ²	156	2,3,3',4,4',5-Hexachlorobiphenyl	ug/kg	3.99E-04	47.0	27	26	1	96%	-
PCB Congeners ²	157	2,3,3',4,4',5'-Hexachlorobiphenyl	ug/kg	0.740	0.740	1	1	0	100%	-
PCB Congeners ²	167	2,3',4,4',5,5'-Hexachlorobiphenyl	ug/kg	1.73E-04	8.54	27	25	2	93%	-
PCB Congeners ²	169	3,3',4,4',5,5'-Hexachlorobiphenyl	ug/kg	0.000161	0.000161	27	1	26	4%	-
PCB Congeners ²	189	2,3,3',4,4',5,5'-Heptachlorobiphenyl	ug/kg	9.80E-05	0.741	27	25	2	93%	-
Metals		Aluminum	mg/kg	5360	25800	98	98	0	100%	38000
Metals		Antimony	mg/kg	0.0400	0.698	29	28	1	97%	0.427
Metals		Arsenic	mg/kg	1.10	32.0	42	42	0	100%	5.86
Metals		Barium	mg/kg	25.8	283	98	98	0	100%	315
Metals		Beryllium	mg/kg	0.100	0.600	98	83	15	85%	0.847
Metals		Cadmium	mg/kg	0.171	4.10	98	56	42	57%	0.674
Metals		Chromium	mg/kg	10.1	620	98	98	0	100%	28
Metals		Cobalt	mg/kg	4.82	22.9	42	42	0	100%	15.2
Metals		Copper	mg/kg	11.3	284	99	99	0	100%	55.6
Metals		Lead	mg/kg	2.90	121	99	99	0	100%	14.5
Metals		Manganese	mg/kg	202	773	24	24	0	100%	-
Metals		Mercury	mg/kg	0.00800	0.536	42	36	6	86%	0.214
Metals		Nickel	mg/kg	6.39	520	98	98	0	100%	21.2
Metals		Selenium ¹	mg/kg	0.400	0.800	92	3	89	3%	2
Metals		Silver	mg/kg	2.00	2.00	24	1	23	4%	-
Metals		Thallium	mg/kg	0.0910	0.600	98	68	30	69%	0.354
Metals		Vanadium	mg/kg	19.3	89.9	42	42	0	100%	70.6
Metals		Zinc	mg/kg	46.0	226	98	98	0	100%	106
NWTPH-Dx		Diesel Range Organics	mg/kg	2.30	54.0	42	35	7	83%	-
NWTPH-Dx		Residual Range Organics	mg/kg	5.90	180	42	32	10	76%	-
Butyltins		Dibutyltin Cation	ug/Kg	-	-	7	0	7	0%	-
Butyltins		Dibutyltin dichloride	ug/kg	4.60	4.60	24	1	23	4%	-
Butyltins		Monobutyltin trichloride	ug/kg	-	-	24	0	24	0%	-
Butyltins		Monobutyltin	ug/Kg	-	-	7	0	7	0%	-
Butyltins		Tetrabutyltin	ug/Kg	-	-	21	0	21	0%	-
Butyltins		Tributyltin chloride	ug/kg	13.0	13.0	24	1	23	4%	-
Butyltins		Tri-n-butyltin	ug/Kg	-	-	7	0	7	0%	-
Dioxins/Furans		1,2,3,4,6,7,8-HpCDD	ug/kg	-	-	2	0	2	0%	-
Dioxins/Furans		1,2,3,4,6,7,8-HpCDF	ug/kg	-	-	2	0	2	0%	-
Dioxins/Furans		1,2,3,4,7,8,9-HpCDF	ug/kg	-	-	2	0	2	0%	-
Dioxins/Furans		1,2,3,4,7,8-HxCDD	ug/kg	-	-	2	0	2	0%	-
Dioxins/Furans		1,2,3,4,7,8-HxCDF	ug/kg	-	-	2	0	2	0%	-
Dioxins/Furans		1,2,3,6,7,8-HxCDD	ug/kg	-	-	2	0	2	0%	-
Dioxins/Furans		1,2,3,6,7,8-HxCDF	ug/kg	-	-	2	0	2	0%	-
Dioxins/Furans		1,2,3,7,8,9-HxCDD	ug/kg	-	-	2	0	2	0%	-
Dioxins/Furans		1,2,3,7,8,9-HxCDF	ug/kg	-	-	2	0	2	0%	-
Dioxins/Furans		1,2,3,7,8-PeCDD	ug/kg	-	-	2	0	2	0%	-
Dioxins/Furans		1,2,3,7,8-PeCDF	ug/kg	-	-	2	0	2	0%	-
Dioxins/Furans		2,3,4,6,7,8-HxCDF	ug/kg	-	-	2	0	2	0%	-
Dioxins/Furans		2,3,4,7,8-PeCDF	ug/kg	-	-	2	0	2	0%	-
Dioxins/Furans		2,3,7,8-TCDD	ug/kg	-	-	2	0	2	0%	-
Dioxins/Furans		2,3,7,8-TCDF	ug/kg	-	-	2	0	2	0%	-
Dioxins/Furans		OCDD	ug/kg	0.0140	0.0140	2	1	1	50%	-
Dioxins/Furans		OCDF	ug/kg	-	-	2	0	2	0%	-
Herbicides		2,4,5-T	ug/Kg	-	-	7	0	7	0%	-
Herbicides		2,4,5-TP (Silvex)	ug/Kg	-	-	7	0	7	0%	-
Herbicides		2,4-D	ug/Kg	-	-	7	0	7	0%	-
Herbicides		2,4-DB	ug/Kg	-	-	7	0	7	0%	-
Herbicides		Dalapon	ug/Kg	-	-	7	0	7	0%	-
Herbicides		Dicamba	ug/Kg	-	-	7	0	7	0%	-
Herbicides		Dichloroprop	ug/Kg	-	-	7	0	7	0%	-
Herbicides		Dinoseb	ug/Kg	-	-	7	0	7	0%	-
Herbicides		MCPA	ug/Kg	-	-	7	0	7	0%	-
Herbicides		MCPP	ug/Kg	-	-	7	0	7	0%	-
Pesticides		4,4'-DDD	ug/Kg	0.150	0.150	21	1	20	5%	-
Pesticides		4,4'-DDE	ug/Kg	0.290	1.20	21	3	18	14%	-
Pesticides		4,4'-DDT	ug/Kg	0.900	140	21	4	17	19%	-
Pesticides		Aldrin	ug/Kg	-	-	21	0	21	0%	-
Pesticides		BHC (alpha)	ug/Kg	-	-	21	0	21	0%	-
Pesticides		BHC (beta)	ug/Kg	-	-	21	0	21	0%	-
Pesticides		BHC (delta)	ug/Kg	-	-	21	0	21	0%	-

Table 2-1
Detection Frequency and Upper Prediction Limit Screening of River OU Sediment Data

metals only
[max] > UPL

Rate > 5%

Analyte Group	IUPAC Number	Analyte	Units	Minimum Detected	Maximum Detected	Results Enumeration				Site-Specific Reference Metal UPLs
						Total	Detect	Non-Detect	Detection Rate	
Pesticides		BHC (gamma) Lindane	ug/Kg	0.0800	0.220	21	2	19	10%	-
Pesticides		Chlordane (alpha)	ug/Kg	-	-	21	0	21	0%	-
Pesticides		Chlordane (gamma)	ug/Kg	0.160	44.0	21	7	14	33%	-
Pesticides		Dieldrin	ug/Kg	-	-	21	0	21	0%	-
Pesticides		Endosulfan I	ug/Kg	-	-	21	0	21	0%	-
Pesticides		Endosulfan II	ug/Kg	-	-	21	0	21	0%	-
Pesticides		Endosulfan Sulfate	ug/Kg	-	-	21	0	21	0%	-
Pesticides		Endrin Aldehyde	ug/Kg	0.670	8.20	21	4	17	19%	-
Pesticides		Endrin Ketone	ug/Kg	0.320	0.320	21	1	20	5%	-
Pesticides		Endrin	ug/Kg	0.540	7.40	21	4	17	19%	-
Pesticides		Heptachlor Epoxide	ug/Kg	0.440	0.440	21	1	20	5%	-
Pesticides		Heptachlor	ug/Kg	-	-	21	0	21	0%	-
Pesticides		Methoxychlor	ug/Kg	-	-	21	0	21	0%	-
Pesticides		Total DDx (MDL-based)	ug/Kg	1.06	199	21	6	15	29%	-
Pesticides		Total DDx (MRL-based)	ug/Kg	1.41	199	21	6	15	29%	-
Pesticides		Toxaphene	ug/Kg	-	-	21	0	21	0%	-
SVOCs		Benzo(a)anthracene	ug/kg	1.60	890	116	46	70	40%	-
SVOCs		Benzo(a)pyrene	ug/kg	1.70	1300	116	43	73	37%	-
SVOCs		Benzo(b)fluoranthene	ug/kg	4.00	750	116	44	72	38%	-
SVOCs		Benzo(g,h,i)perylene	ug/kg	2.60	870	116	35	81	30%	-
SVOCs		Benzo(k)fluoranthene	ug/kg	2.30	715	116	39	77	34%	-
SVOCs		Chrysene	ug/kg	1.40	1200	116	54	62	47%	-
SVOCs		Dibenz(a,h)anthracene	ug/kg	2.50	320	116	10	106	9%	-
SVOCs		Fluoranthene	ug/kg	2.50	1700	116	51	65	44%	-
SVOCs		Indeno(1,2,3-cd)pyrene	ug/kg	2.20	960	116	35	81	30%	-
SVOCs		Pyrene	ug/kg	1.80	2000	116	54	62	47%	-
SVOCs		Total HPAHs (KM-capped, MDL-based)	ug/kg	15.4	8200	116	59	57	51%	-
SVOCs		Total HPAHs (KM-capped, MRL-based)	ug/kg	16.5	8200	116	59	57	51%	-
SVOCs		2-Methylnaphthalene	ug/kg	-	-	94	0	94	0%	-
SVOCs		Acenaphthene	ug/kg	2.80	53	116	4	112	3%	-
SVOCs		Acenaphthylene	ug/kg	-	-	94	0	94	0%	-
SVOCs		Anthracene	ug/kg	1.50	140	116	11	105	9%	-
SVOCs		Fluorene	ug/kg	14.0	29.0	116	2	114	2%	-
SVOCs		Naphthalene	ug/kg	-	-	94	0	94	0%	-
SVOCs		Phenanthrene	ug/kg	1.40	510	116	45	71	39%	-
SVOCs		Total LPAHs (KM, capped, MDL-based)	ug/kg	5.50	688	116	45	71	39%	-
SVOCs		Total LPAHs (KM, capped, MRL-based)	ug/kg	23.5	746	116	45	71	39%	-
SVOCs		cPAH BaPEQs (KM-capped, MDL-based)	ug/kg	0.358	1873	116	56	60	48%	-
SVOCs		cPAH BaPEQs (KM-capped, MRL-based)	ug/kg	0.441	1873	116	56	60	48%	-
SVOCs		1,2,4-Trichlorobenzene	ug/kg	-	-	24	0	24	0%	-
SVOCs		1,2-Dichlorobenzene	ug/kg	-	-	24	0	24	0%	-
SVOCs		1,3-Dichlorobenzene	ug/kg	-	-	24	0	24	0%	-
SVOCs		1,4-Dichlorobenzene	ug/kg	-	-	24	0	24	0%	-
SVOCs		1-Methylnaphthalene	ug/kg	-	-	2	0	2	0%	-
SVOCs		2,4,5-Trichlorophenol	ug/kg	-	-	24	0	24	0%	-
SVOCs		2,4,6-Trichlorophenol	ug/kg	-	-	24	0	24	0%	-
SVOCs		2,4-Dichlorophenol	ug/kg	-	-	24	0	24	0%	-
SVOCs		2,4-Dimethylphenol	ug/kg	-	-	24	0	24	0%	-
SVOCs		2,4-Dinitrophenol	ug/kg	-	-	24	0	24	0%	-
SVOCs		2,4-Dinitrotoluene	ug/kg	-	-	24	0	24	0%	-
SVOCs		2,6-Dinitrotoluene	ug/kg	-	-	24	0	24	0%	-
SVOCs		2-Chloronaphthalene	ug/kg	-	-	24	0	24	0%	-
SVOCs		2-Chlorophenol	ug/kg	-	-	24	0	24	0%	-
SVOCs		2-Methylphenol	ug/kg	-	-	24	0	24	0%	-
SVOCs		2-Nitroaniline	ug/kg	-	-	24	0	24	0%	-
SVOCs		2-Nitrophenol	ug/kg	-	-	24	0	24	0%	-
SVOCs		3,3'-Dichlorobenzidine	ug/kg	-	-	24	0	24	0%	-
SVOCs		3-Nitroaniline	ug/kg	-	-	24	0	24	0%	-
SVOCs		4,6-Dinitro-2-methylphenol	ug/kg	-	-	24	0	24	0%	-
SVOCs		4-Bromophenyl Phenyl Ether	ug/kg	-	-	24	0	24	0%	-
SVOCs		4-Chloro-3-methylphenol	ug/kg	-	-	24	0	24	0%	-
SVOCs		4-Chloroaniline	ug/kg	-	-	24	0	24	0%	-
SVOCs		4-Chlorophenyl Phenyl Ether	ug/kg	-	-	24	0	24	0%	-
SVOCs		4-Nitroaniline	ug/kg	-	-	24	0	24	0%	-
SVOCs		4-Nitrophenol	ug/kg	-	-	24	0	24	0%	-
SVOCs		Aniline	ug/kg	-	-	24	0	24	0%	-
SVOCs		Benzoic Acid	ug/kg	300	300	24	1	23	4%	-
SVOCs		Benzyl Alcohol	ug/kg	22.0	22.0	24	1	23	4%	-
SVOCs		Bis(2-chloroethoxy)methane	ug/kg	-	-	24	0	24	0%	-
SVOCs		Bis(2-chloroethyl) Ether	ug/kg	-	-	24	0	24	0%	-
SVOCs		Bis(2-chloroisopropyl) Ether	ug/kg	-	-	24	0	24	0%	-
SVOCs		Bis(2-ethylhexyl) Phthalate	ug/kg	7.50	3800	63	23	40	37%	-
SVOCs		Butyl Benzyl Phthalate	ug/kg	10.0	10.0	42	1	41	2%	-
SVOCs		Carbazole	ug/kg	1.40	120	48	5	43	10%	-
SVOCs		Dibenzofuran	ug/kg	11.0	11.0	94	1	93	1%	-
SVOCs		Diethyl Phthalate	ug/kg	21.0	21.0	24	1	23	4%	-
SVOCs		Dimethyl Phthalate	ug/kg	-	-	24	0	24	0%	-
SVOCs		Di-n-butyl Phthalate	ug/kg	8.80	87.0	42	7	35	17%	-
SVOCs		Di-n-octyl Phthalate	ug/kg	-	-	42	0	42	0%	-
SVOCs		Hexachlorobenzene	ug/kg	-	-	24	0	24	0%	-
SVOCs		Hexachlorobutadiene	ug/kg	-	-	24	0	24	0%	-
SVOCs		Hexachlorocyclopentadiene	ug/kg	-	-	24	0	24	0%	-
SVOCs		Hexachloroethane	ug/kg	-	-	24	0	24	0%	-
SVOCs		Isophorone	ug/kg	-	-	24	0	24	0%	-
SVOCs		Nitrobenzene	ug/kg	-	-	24	0	24	0%	-
SVOCs		N-Nitrosodimethylamine	ug/kg	-	-	24	0	24	0%	-
SVOCs		N-Nitrosodi-n-propylamine	ug/kg	-	-	24	0	24	0%	-

Table 2-1
Detection Frequency and Upper Prediction Limit Screening of River OU Sediment Data

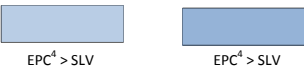
Analyte Group	IUPAC Number	Analyte	Units	Minimum Detected	Maximum Detected	Results Enumeration				Site-Specific Reference Metal UPLs
						Total	Detect	Non-Detect	Detection Rate	
SVOCs		N-Nitrosodiphenylamine	ug/kg	-	-	24	0	24	0%	-
SVOCs		p-cresol (4-Methylphenol)	ug/kg	4.80	180	42	8	34	19%	-
SVOCs		Pentachlorophenol	ug/kg	-	-	24	0	24	0%	-
SVOCs		Phenol	ug/kg	24.0	24.0	24	1	23	4%	-
GenChem-TOC		Carbon, Total Organic	%	0.0890	2.30	99	99	0	100%	-
GenChem-Total Solids		Solids, Total	%	29.4	83.4	103	103	0	100%	-

Notes

- (1) Due to lack of site-specific reference value, the background value from DEQ (2007) was used.
(2) Only dioxin-like PCB congeners are shown on this table.

- = no value
% = percent
ug/kg = micrograms per kilogram
BHC = hexachlorocyclohexane
HPAH = high molecular weight polycyclic aromatic hydrocarbons
Max = maximum
mg/kg = milligram per kilogram
NWTPH-Dx = northwest total petroleum hydrocarbon-diesel-extended
PCB = polychlorinated biphenyl
SVOC = semi-volatile organic carbon
TOC = total organic carbon
UPL = Upper Prediction Limit
VOC = volatile organic carbon

Table 2-2
Human Health Screening of River OU Sediment Data



Analyte Group	IUPAC Number	Analyte ^{2,3}	Units	Maximum Detected	95% UCL	Human Health Bioaccumulative SLVs		Retain as COPC?	
						Subsistence Fisher	Recreational Angler	Subsistence Fisher	Recreational Fisher
PCB Aroclors		Aroclor 1248	ug/kg	140	-	0.048	0.39	Yes	Yes
PCB Aroclors		Aroclor 1254	ug/kg	22000	2387	0.048	0.39	Yes	Yes
PCB Aroclors		Aroclor 1260	ug/kg	140	5.10	0.048	0.39	Yes	Yes
PCB Aroclors		Total PCBs as Aroclors (MDL-based)	ug/kg	22191	2404	0.048	0.39	Yes	Yes
PCB Aroclors		Total PCBs as Aroclors (MRL-based)	ug/kg	22560	2441	0.048	0.39	Yes	Yes
PCB Congeners		Total PCBs as Congeners (KM-based, capped)	ug/kg	4312	1836	0.048	0.39	Yes	Yes
PCB Congeners		PCB TEQ (Mammals) as Calculated from Dioxin-Like PCB Congeners (KM-capped, RDL-based)	ug/kg	0.0133	0.00575	0.0000011	0.0000091	Yes	Yes
PCB Congeners ¹	77	3,3',4,4'-Tetrachlorobiphenyl	ug/kg	0.530	0.231	0.0064	0.052	Yes	Yes
PCB Congeners ¹	81	3,4,4',5-Tetrachlorobiphenyl	ug/kg	0.0320	0.0146	0.0021	0.017	Yes	No
PCB Congeners ¹	105	2,3,3',4,4'-Pentachlorobiphenyl	ug/kg	98.4	43.1	0.021	0.17	Yes	Yes
PCB Congeners ¹	114	2,3,4,4',5-Pentachlorobiphenyl	ug/kg	5.34	2.34	0.021	0.17	Yes	Yes
PCB Congeners ¹	118	2,3',4,4',5-Pentachlorobiphenyl	ug/kg	233	104	0.026	0.12	Yes	Yes
PCB Congeners ¹	123	2,3',4,4',5'-Pentachlorobiphenyl	ug/kg	3.13	1.37	0.026	0.21	Yes	Yes
PCB Congeners ¹	126	3,3',4,4',5-Pentachlorobiphenyl	ug/kg	2.96E-04	0.000187	0.0000062	0.00005	Yes	Yes
PCB Congeners ¹	156	2,3,3',4,4',5-Hexachlorobiphenyl	ug/kg	47.0	19.8	0.026	0.21	Yes	Yes
PCB Congeners ¹	157	2,3,3',4,4',5'-Hexachlorobiphenyl	ug/kg	0.740	-	0.026	0.21	Yes	Yes
PCB Congeners ¹	167	2,3',4,4',5,5'-Hexachlorobiphenyl	ug/kg	8.54	4.24	0.026	0.21	Yes	Yes
PCB Congeners ¹	169	3,3',4,4',5,5'-Hexachlorobiphenyl	ug/kg	0.000161	-	0.000021	0.21	Yes	No
PCB Congeners ¹	189	2,3,3',4,4',5,5'-Heptachlorobiphenyl	ug/kg	0.741	0.320	0.14	1.2	Yes	No
Metals		Antimony	mg/kg	0.698	0.233	-	-	No	No
Metals		Arsenic	mg/kg	32.0	7.98	5.86	5.86	Yes	Yes
Metals		Cadmium	mg/kg	4.10	0.511	0.674	0.674	No	No
Metals		Chromium	mg/kg	620	39.1	-	-	No	No
Metals		Cobalt	mg/kg	22.9	10.7	-	-	No	No
Metals		Copper	mg/kg	284	38.6	-	-	No	No
Metals		Lead	mg/kg	121	14.6	14.5	14.5	Yes	Yes
Metals		Manganese	mg/kg	773	494	-	-	Yes - no SLV	Yes - no SLV
Metals		Mercury	mg/kg	0.536	0.138	0.214	0.214	No	No
Metals		Nickel	mg/kg	520	33.2	-	-	No	No
Metals		Silver	mg/kg	2.00	-	-	-	No	No
Metals		Thallium	mg/kg	0.600	0.229	0.354	0.354	No	No
Metals		Vanadium	mg/kg	89.9	50.8	-	-	No	No
Metals		Zinc	mg/kg	226	109	106	106	Yes	Yes
Butyltins		Dibutyltin dichloride	ug/kg	4.60	-	10	85	No	No
Butyltins		Tributyltin chloride	ug/kg	13.0	-	10	85	Yes	No
Dioxins/Furans		OCDD	ug/kg	0.0140	-	2.8	23	No	No
Pesticides		4,4'-DDD	ug/Kg	0.150	-	0.04	0.33	Yes	No
Pesticides		4,4'-DDE	ug/Kg	1.20	0.365	0.04	0.33	Yes	Yes
Pesticides		4,4'-DDT	ug/Kg	140	22.3	0.04	0.33	Yes	Yes
Pesticides		BHC (gamma) Lindane	ug/Kg	0.220	0.0745	2.3	19	No	No
Pesticides		Chlordane (gamma)	ug/Kg	44.0	6.94	0.046	0.37	Yes	Yes
Pesticides		Endrin Aldehyde	ug/Kg	8.20	1.83	-	-	Yes - no SLV	Yes - no SLV
Pesticides		Endrin Ketone	ug/Kg	0.320	-	-	-	Yes - no SLV	Yes - no SLV
Pesticides		Endrin	ug/Kg	7.40	1.49	-	-	Yes - no SLV	Yes - no SLV
Pesticides		Heptachlor Epoxide	ug/Kg	0.440	-	-	-	Yes - no SLV	Yes - no SLV
Pesticides		Total DDx (MDL-based)	ug/Kg	199	121	0.04	0.33	Yes	Yes
Pesticides		Total DDx (MRL-based)	ug/Kg	199	33.3	0.04	0.33	Yes	Yes
SVOCs		Benzo(a)anthracene	ug/kg	890	40.2	47000	380000	No	No
SVOCs		Benzo(a)pyrene	ug/kg	1300	47.1	47000	380000	No	No
SVOCs		Benzo(b)fluoranthene	ug/kg	750	35.7	47000	380000	No	No
SVOCs		Benzo(g,h,i)perylene	ug/kg	870	28.7	47000	380000	No	No
SVOCs		Benzo(k)fluoranthene	ug/kg	715	33.1	47000	380000	No	No
SVOCs		Chrysene	ug/kg	1200	53.1	47000	380000	No	No
SVOCs		Dibenz(a,h)anthracene	ug/kg	320	11.2	47000	380000	No	No
SVOCs		Fluoranthene	ug/kg	1700	69.5	62000	510000	No	No
SVOCs		Indeno(1,2,3-cd)pyrene	ug/kg	960	34.6	47000	380000	No	No
SVOCs		Pyrene	ug/kg	2000	76.5	47000	380000	No	No
SVOCs		Acenaphthene	ug/kg	53	3.01	62000	510000	No	No
SVOCs		Anthracene	ug/kg	140	6.08	62000	510000	No	No
SVOCs		Fluorene	ug/kg	29.0	2.07	62000	510000	No	No
SVOCs		Phenanthrene	ug/kg	510	25.5	62000	510000	No	No
SVOCs		cPAH BaPEQs (KM-capped, MDL-based)	ug/kg	1873	111	47000	380000	No	No
SVOCs		cPAH BaPEQs (KM-capped, MRL-based)	ug/kg	1873	74.3	47000	380000	No	No
SVOCs		Benzoic Acid	ug/kg	300	-	-	-	No	No
SVOCs		Benzyl Alcohol	ug/kg	22.0	-	-	-	No	No
SVOCs		Bis(2-ethylhexyl) Phthalate	ug/kg	3800	526	-	-	Yes - no SLV	Yes - no SLV
SVOCs		Butyl Benzyl Phthalate	ug/kg	10.0	-	-	-	Yes - no SLV	Yes - no SLV
SVOCs		Carbazole	ug/kg	120	11.1	-	-	Yes - no SLV	Yes - no SLV
SVOCs		Dibenzofuran	ug/kg	11.0	-	-	-	Yes - no SLV	Yes - no SLV
SVOCs		Diethyl Phthalate	ug/kg	21.0	-	-	-	No	No
SVOCs		Di-n-butyl Phthalate	ug/kg	87.0	15.9	-	-	Yes - no SLV	Yes - no SLV
SVOCs		p-cresol (4-Methylphenol)	ug/kg	180	16.1	-	-	No	No
SVOCs		Phenol	ug/kg	24.0	-	-	-	No	No

Notes

(1) Only dioxin-like PCB congeners are shown on this table.

(2) Only detected analytes are shown in this table.

(3) Only metals with greater than Reference Area are shown in this table.

(4) The EPC is the 95% UCL, if calculated; otherwise maximum detected concentration.

guidance (pyrene)

- = no value

% = percent

ug/kg = micrograms per kilogram

BHC = hexachlorocyclohexane

HPAH = high molecular weight polycyclic aromatic hydrocarbons

Max = maximum

mg/kg = milligram per kilogram

NWTPH-Dx = northwest total petroleum hydrocarbon-diesel-extended

PCB = polychlorinated biphenyl

SLV = screening level value

SVOC = semi-volatile organic carbon

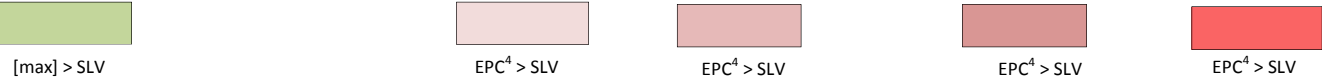
TOC = total organic carbon

UPL = Upper Prediction Limit

Table 2-3
Ecological Screening of River OU Sediment Data

<div><div></div><div>[max] > SLV</div><div></div><div>EPC⁴ > SLV</div><div></div><div>EPC⁴ > SLV</div><div></div><div>EPC⁴ > SLV</div><div></div><div>EPC⁴ > SLV</div></div>																
Analyte Group	IUPAC Number	Analyte ^{2,3}	Units	Maximum Detected	95% UCL	Benthic Community			ODEQ Wildlife Bioaccumulative SLVs						Retain as CPEC?	
						ODEQ SLVs	WDOE SCO	WDOE CSL	Freshwater Fish	Birds Individual	Birds Population	Mammals Individual	Mammals Population	Lowest Wildlife SLV	Direct Toxicity	Bioaccumulation
PCB Aroclors		Aroclor 1248	ug/kg	140	-	21	-	-	22	1.8	91	44	84	1.8	Yes	Yes
PCB Aroclors		Aroclor 1254	ug/kg	22000	2387	7	-	-	22	1.8	91	44	84	1.8	Yes	Yes
PCB Aroclors		Aroclor 1260	ug/kg	140	5.10	7	-	-	22	1.8	91	44	84	1.8	Yes	Yes
PCB Aroclors		Total PCBs as Aroclors (MDL-based)	ug/kg	22191	2404	34	110	2500	22	1.8	91	44	84	1.8	Yes	Yes
PCB Aroclors		Total PCBs as Aroclors (MRL-based)	ug/kg	22560	2441	34	110	2500	22	1.8	91	44	84	1.8	Yes	Yes
PCB Congeners		Total PCBs as Congeners (KM-based, capped)	ug/kg	4312	1836	34	-	-	22	1.8	91	44	84	1.8	Yes	Yes
PCB Congeners		PCB TEQ (Bird) as Calculated from Dioxin-Like PCB Congeners (KM-capped, RDL-based)	ug/kg	0.0496	0.0145	-	-	-	-	0.0007	0.0035	-	-	0.0007	-	Yes
PCB Congeners		PCB TEQ (Fish) as Calculated from Dioxin-Like PCB Congeners (KM-capped, RDL-based)	ug/kg	0.00215	0.000933	-	-	-	0.00056	-	-	-	-	0.00056	-	Yes
PCB Congeners		PCB TEQ (Mammals) as Calculated from Dioxin-Like PCB Congeners (KM-capped, RDL-based)	ug/kg	0.0133	0.00575	-	-	-	-	-	-	0.000052	0.0014	0.000052	-	Yes
PCB Congeners ¹	77	3,3',4,4'-Tetrachlorobiphenyl	ug/kg	0.530	0.231	-	-	-	3.2	0.008	0.04	0.3	8.1	0.008	-	Yes
PCB Congeners ¹	81	3,4,4',5-Tetrachlorobiphenyl	ug/kg	0.0320	0.0146	-	-	-	0.65	0.004	0.02	0.098	2.7	0.004	-	Yes
PCB Congeners ¹	105	2,3,3',4,4'-Pentachlorobiphenyl	ug/kg	98.4	43.1	-	-	-	62	3.9	19	0.94	26	0.94	-	Yes
PCB Congeners ¹	114	2,3,4,4',5-Pentachlorobiphenyl	ug/kg	5.34	2.34	-	-	-	65	40	200	0.98	27	0.98	-	Yes
PCB Congeners ¹	118	2,3',4,4',5-Pentachlorobiphenyl	ug/kg	233	104	-	-	-	79	49	240	1.2	33	1.2	-	Yes
PCB Congeners ¹	123	2,3',4,4',5'-Pentachlorobiphenyl	ug/kg	3.13	1.37	-	-	-	79	49	240	1.2	33	1.2	-	Yes
PCB Congeners ¹	126	3,3',4,4',5-Pentachlorobiphenyl	ug/kg	2.96E-04	0.000187	-	-	-	0.062	0.0039	0.019	0.00028	0.0078	0.00028	-	No
PCB Congeners ¹	156	2,3,3',4,4',5-Hexachlorobiphenyl	ug/kg	47.0	19.8	-	-	-	79	4.9	24	1.2	33	1.2	-	Yes
PCB Congeners ¹	157	2,3,3',4,4',5'-Hexachlorobiphenyl	ug/kg	0.740	-	-	-	-	79	4.9	24	1.2	33	1.2	-	No
PCB Congeners ¹	167	2,3',4,4',5,5'-Hexachlorobiphenyl	ug/kg	8.54	4.24	-	-	-	79	49	240	1.2	33	1.2	-	Yes
PCB Congeners ¹	169	3,3',4,4',5,5'-Hexachlorobiphenyl	ug/kg	0.000161	-	-	-	-	79	0.49	2.4	0.0012	0.033	0.0012	-	No
PCB Congeners ¹	189	2,3,3',4,4',5,5'-Heptachlorobiphenyl	ug/kg	0.741	0.320	-	-	-	430	270	1400	6.6	180	6.6	-	No
Metals		Antimony	mg/kg	0.698	0.233	3	-	-	-	-	-	-	-	-	No	No
Metals		Arsenic	mg/kg	32.0	7.98	6	14	120	5.86	5.86	5.86	5.86	5.86	5.86	Yes	Yes
Metals		Cadmium	mg/kg	4.10	0.511	0.674	2.1	5.4	0.674	0.674	0.674	0.674	0.674	0.674	Yes	No
Metals		Chromium	mg/kg	620	39.1	37	72	82	-	-	-	-	-	-	Yes	No
Metals		Cobalt	mg/kg	22.9	10.7	15.2	-	-	-	-	-	-	-	-	Yes	No
Metals		Copper	mg/kg	284	38.6	55.6	400	1200	-	-	-	-	-	-	Yes	No
Metals		Lead	mg/kg	121	14.6	35	360	>1300	14.5	14.5	14.5	14.5	14.5	14.5	Yes	Yes
Metals		Manganese	mg/kg	773	494	1100	-	-	-	-	-	-	-	-	No	Yes - no SLV
Metals		Mercury	mg/kg	0.536	0.138	0.214	0.66	0.8	0.214	0.214	0.214	0.214	0.214	0.214	Yes	No
Metals		Nickel	mg/kg	520	33.2	21.2	26	110	-	-	-	-	-	-	Yes	No
Metals		Silver	mg/kg	2.00	-	4.5	0.57	1.7	-	-	-	-	-	-	No	No
Metals		Thallium	mg/kg	0.600	0.229	0.354	-	-	0.354	0.354	0.354	0.354	0.354	0.354	Yes	No
Metals		Vanadium	mg/kg	89.9	50.8	70.6	-	-	-	-	-	-	-	-	Yes	No

Table 2-3
Ecological Screening of River OU Sediment Data



Analyte Group	IUPAC Number	Analyte ^{2,3}	Units	Maximum Detected	95% UCL	Benthic Community			ODEQ Wildlife Bioaccumulative SLVs						Retain as CPEC?	
						ODEQ SLVs	WDOE SCO	WDOE CSL	Freshwater Fish	Birds Individual	Birds Population	Mammals Individual	Mammals Population	Lowest Wildlife SLV	Direct Toxicity	Bioaccumulation
Metals		Zinc	mg/kg	226	109	123	3200	>4200	106	106	106	106	106	106	Yes	Yes
Butyltins		Dibutyltin dichloride	ug/kg	4.60	-	-	910	130000	2.3	1600	4100	730	1100	2.3	Yes - no SLV	Yes
Butyltins		Tributyltin chloride	ug/kg	13.0	-	-	47	320	2.3	1600	4100	730	1100	2.3	Yes - no SLV	Yes
Dioxins/Furans		OCDD	ug/kg	0.0140	-	-	-	-	4300	5300	27000	130	3600	130	-	No
Pesticides		4,4'-DDD	ug/Kg	0.150	-	4	310	860	0.39	0.095	0.34	4.9	24	0.095	No	Yes
Pesticides		4,4'-DDE	ug/Kg	1.20	0.365	1.5	21	33	0.39	0.095	0.34	4.9	24	0.095	No	Yes
Pesticides		4,4'-DDT	ug/Kg	140	22.3	4	100	8100	0.39	0.095	0.34	4.9	24	0.095	Yes	Yes
Pesticides		BHC (gamma) Lindane	ug/Kg	0.220	0.0745	0.9	-	-	-	-	-	-	-	-	No	Yes - no SLV
Pesticides		Chlordane (gamma)	ug/Kg	44.0	6.94	4.5	-	-	0.5	10	51	28	56	0.5	Yes	Yes
Pesticides		Endrin Aldehyde	ug/Kg	8.20	1.83	3	-	-	-	-	-	-	-	-	Yes	Yes - no SLV
Pesticides		Endrin Ketone	ug/Kg	0.320	-	3	8.5	>8.5	-	-	-	-	-	-	No	Yes - no SLV
Pesticides		Endrin	ug/Kg	7.40	1.49	3	-	-	-	-	-	-	-	-	Yes	Yes - no SLV
Pesticides		Heptachlor Epoxide	ug/Kg	0.440	-	0.6	-	-	-	-	-	-	-	-	No	Yes - no SLV
Pesticides		Total DDx (MDL-based)	ug/Kg	199	121	7	-	-	0.39	0.095	0.34	4.9	24	0.095	Yes	Yes
Pesticides		Total DDx (MRL-based)	ug/Kg	199	33.3	7	-	-	0.39	0.095	0.34	4.9	24	0.095	Yes	Yes
SVOCs		Benzo(a)anthracene	ug/kg	890	40.2	32	-	-	1900	-	-	18000000	90000000	1900	Yes	No
SVOCs		Benzo(a)pyrene	ug/kg	1300	47.1	32	-	-	1900	-	-	18000000	90000000	1900	Yes	No
SVOCs		Benzo(b)fluoranthene	ug/kg	750	35.7	27	-	-	1900	-	-	18000000	90000000	1900	Yes	No
SVOCs		Benzo(g,h,i)perylene	ug/kg	870	28.7	300	-	-	1900	-	-	18000000	90000000	1900	Yes	No
SVOCs		Benzo(k)fluoranthene	ug/kg	715	33.1	27	-	-	1900	-	-	18000000	90000000	1900	Yes	No
SVOCs		Chrysene	ug/kg	1200	53.1	57	-	-	1900	-	-	18000000	90000000	1900	Yes	No
SVOCs		Dibenz(a,h)anthracene	ug/kg	320	11.2	33	-	-	1900	-	-	18000000	90000000	1900	Yes	No
SVOCs		Fluoranthene	ug/kg	1700	69.5	111	-	-	37000	-	-	360000	1800000	37000	Yes	No
SVOCs		Indeno(1,2,3-cd)pyrene	ug/kg	960	34.6	17	-	-	1900	-	-	18000000	90000000	1900	Yes	No
SVOCs		Pyrene	ug/kg	2000	76.5	53	-	-	1900	-	-	18000000	90000000	1900	Yes	No
SVOCs		Total HPAHs (KM-capped, MDL-based)	ug/kg	8200	652	193	-	-	1900	-	-	18000000	90000000	1900	Yes	No
SVOCs		Total HPAHs (KM-capped, MRL-based)	ug/kg	8200	676	193	-	-	1900	-	-	18000000	90000000	1900	Yes	No
SVOCs		Acenaphthene	ug/kg	53	3.01	290	-	-	37000	-	-	360000	1800000	37000	No	No
SVOCs		Anthracene	ug/kg	140	6.08	57	-	-	37000	-	-	360000	1800000	37000	Yes	No
SVOCs		Fluorene	ug/kg	29.0	2.07	77	-	-	37000	-	-	360000	1800000	37000	No	No
SVOCs		Phenanthrene	ug/kg	510	25.5	42	-	-	37000	-	-	360000	1800000	37000	Yes	No
SVOCs		Total LPAHs (KM, capped, MDL-based)	ug/kg	688	42.6	76	-	-	37000	-	-	360000	1800000	37000	Yes	No
SVOCs		Total LPAHs (KM, capped, MRL-based)	ug/kg	746	76.3	76	-	-	37000	-	-	360000	1800000	37000	Yes	No
SVOCs		Benzoic Acid	ug/kg	300	-	-	2900	3800	-	-	-	-	-	-	Yes - no SLV	No
SVOCs		Benzyl Alcohol	ug/kg	22.0	-	-	-	-	-	-	-	-	-	-	Yes - no SLV	No
SVOCs		Bis(2-ethylhexyl) Phthalate	ug/kg	3800	526	750	500	22000	-	-	-	-	-	-	Yes	Yes - no SLV
SVOCs		Butyl Benzyl Phthalate	ug/kg	10.0	-	110	-	-	-	-	-	-	-	-	No	Yes - no SLV
SVOCs		Carbazole	ug/kg	120	11.1	140	-	-	-	-	-	-	-	-	No	Yes - no SLV
SVOCs		Dibenzofuran	ug/kg	11.0	-	5100	200	680	-	-	-	-	-	-	No	Yes - no SLV
SVOCs		Diethyl Phthalate	ug/kg	21.0	-	110	-	-	-	-	-	-	-	-	No	No
SVOCs		Di-n-butyl Phthalate	ug/kg	87.0	15.9	110	380	1000	-	-	-	-	-	-	No	Yes - no SLV
SVOCs		p-cresol (4-Methylphenol)	ug/kg	180	16.1	48	260	2000	-	-	-	-	-	-	Yes	No
SVOCs		Phenol	ug/kg	24.0	-	48	120	210	-	-	-	-	-	-	No	No

Table 2-3
Ecological Screening of River OU Sediment Data

Notes

- (1) Only dioxin-like PCB congeners are shown on this table.
- (2) Only detected analytes are shown in this table.
- (3) Only metals with greater than Reference Area are shown in this table.
- (4) The EPC is the 95% UCL, if calculated; otherwise maximum detected concentration.

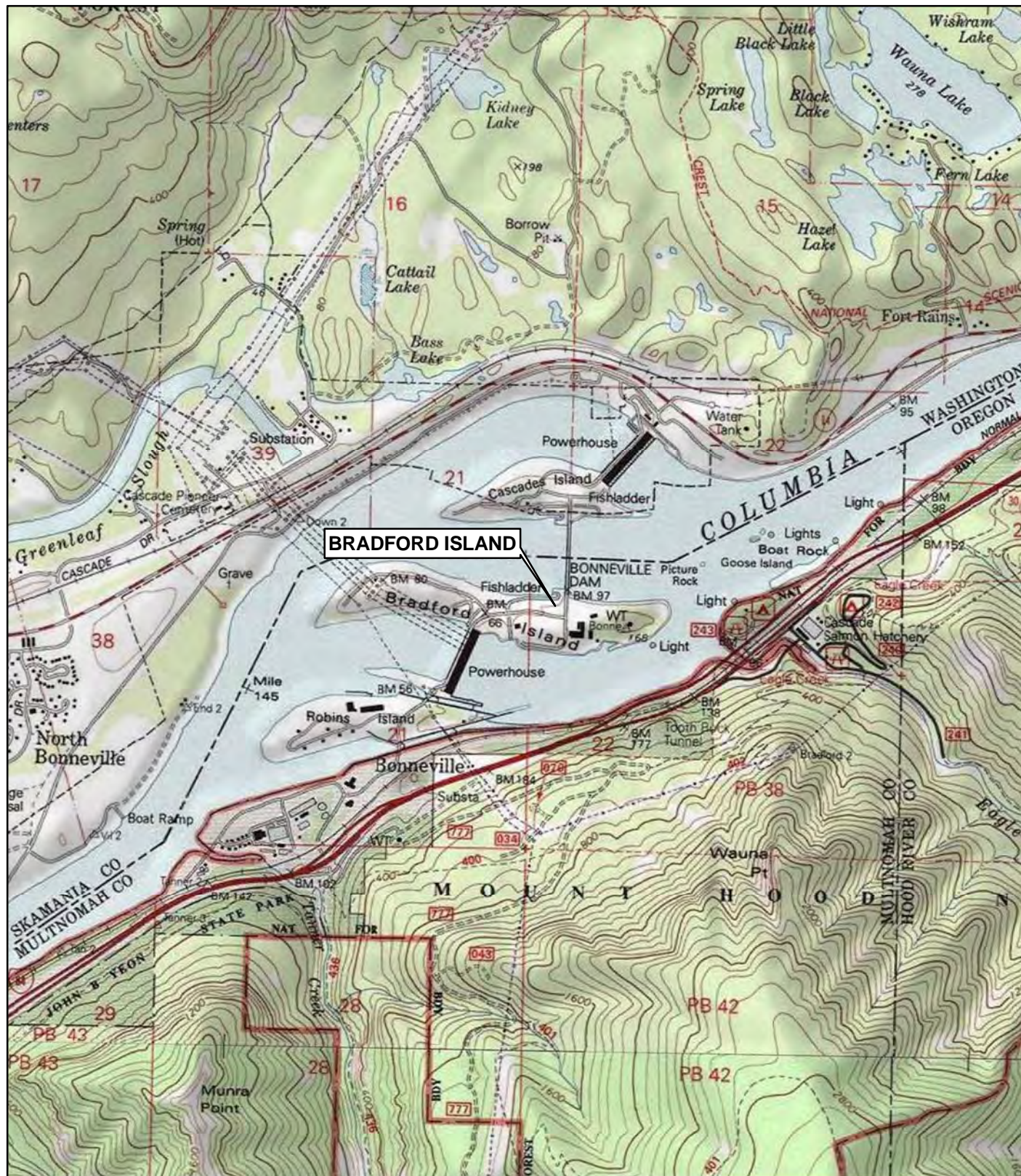
- = no value
% = percent
ug/kg = micrograms per kilogram
BHC = hexachlorocyclohexane
CSL = cleanup screening level
HPAH = high molecular weight polycyclic aromatic hydrocarbons
Max = maximum
mg/kg = milligram per kilogram

NWTPH-Dx = northwest total petroleum hydrocarbon-diesel-extended
ODEQ = Oregon Department of Environmental Quality
PCB = polychlorinated biphenyl
SCO = sediment cleanup objective
SLV = screening level value
SVOC = semi-volatile organic carbon
TOC = total organic carbon
UPL = Upper Prediction Limit
VOC = volatile organic carbon
WDOE = Washington Department of Ecology

Table 2-4
Summary of Variogram Models

Analyte	Unit	Nugget Effect (Unit ²)	Sill (Unit ²)	Range – Major/Minor (feet)
Arsenic	mg/kg	20	20	100 / 20
Mercury	mg/kg	0	0.01	400 / 40
Nickel	mg/kg	0	3,000	100 / 20
Total HPAHs	ug/kg	400,000	1,000,000	400 / 50
Total Aroclors	ug/kg	8,000,000	2,000,000	50 / 20

FIGURES



Source: Bonneville Dam (45121f8) 7.5 Minute USGS Topographic Map, 1994.

0 1,000 2,000 Feet
|-----|-----|-----|

VICINITY MAP

URS


25696528

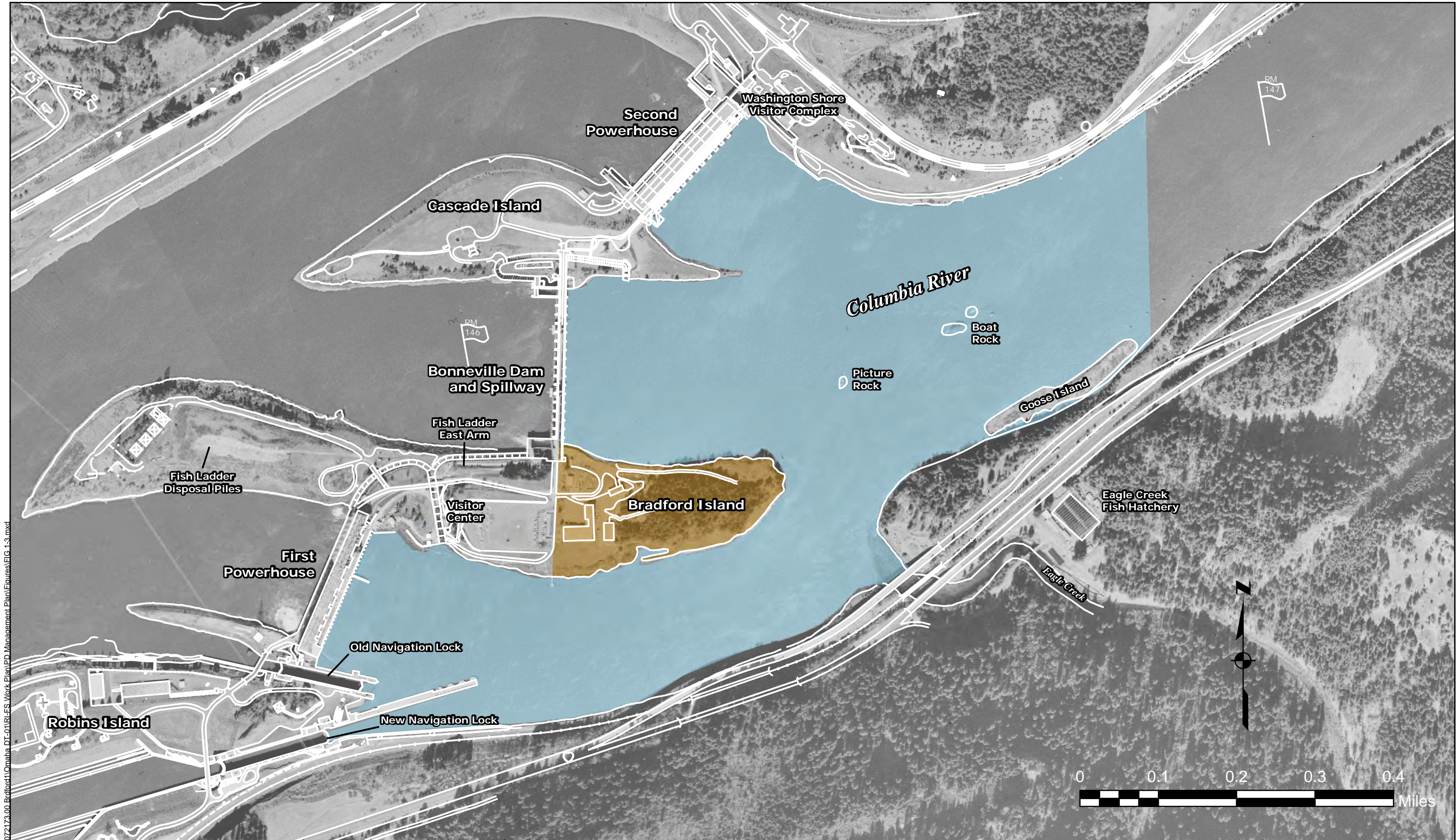
BRADFORD ISLAND
CASCADE LOCKS, OREGON

FIGURE 1-1



Q:\25692709 USACE\63-F0072173.00 Bradford\1\Ft.Worth DT-02\RI Report Working Folder\RI Text\Figures\FIG 1-2.mxd

O:\25692709 USACE\B3-	JOB No. 25696528	DESIGNED: LSM	PROJ. ENGINEER: LSM	 111 S.W. Columbia, Suite 1500 Portland, Oregon 97201 (tel) 503-222-7200 (fax) 503-222-4292 www.urscorp.com	BRADFORD ISLAND	DRAWING NUMBER: FIGURE 1-2 GIS FILE NUMBER: FIG 1-2 SHEET: REV:
		DRAWN BY: SB	APPROVED BY: MP		CASCADE LOCKS, OREGON	
		CHECKED BY: SB	DATE: JULY 2010			
					BONNEVILLE DAM COMPLEX	



Q:\26692709_USACE\53-F0072173-00_Bridford\Omaha DT-01\RFES Work Plan\PD Management Plan\Figures\FIG 1-3.mxd

Legend

-  Upland OU
-  River OU

JOB No. 25696528	DESIGNED: LSM	PROJ. ENGINEER: LSM
	DRAWN BY: SB	APPROVED BY: MP
	CHECKED BY: SB	DATE: JULY 2010



111 S.W. Columbia, Suite 1500
Portland, Oregon 97201
(tel) 503-222-7200
(fax) 503-222-4292
www.urscorp.com

BRADFORD ISLAND

CASCADE LOCKS, OREGON

LOCATION OF OPERABLE UNITS


DRAWING NUMBER:
FIGURE 1-3

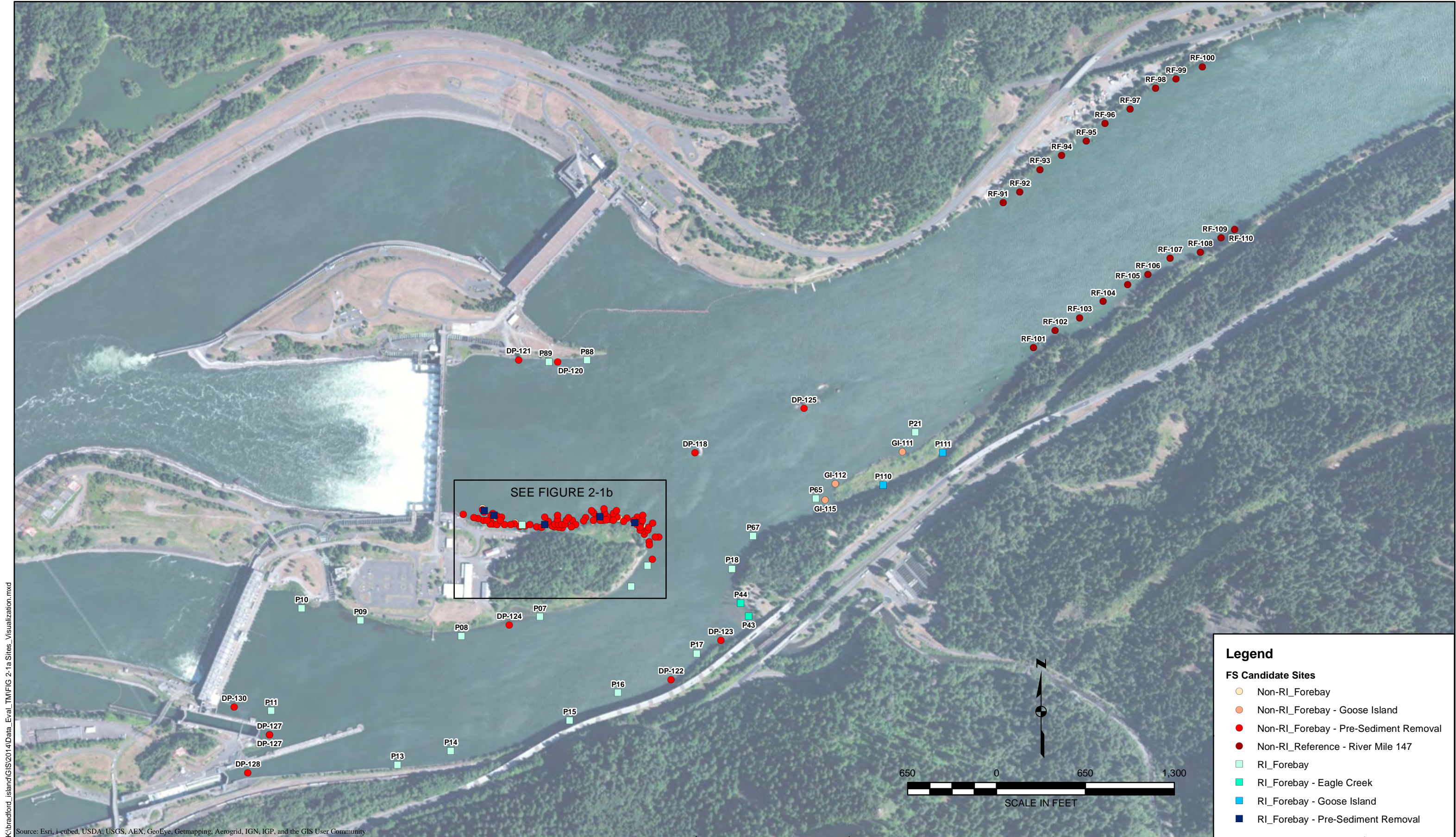
GIS FILE NUMBER:
FIG 1-3

SHEET: REV:




K:\bradford_island\GIS\2014\Data Eval_TMF\FIG 1-4 River OU.mxd

	JOB No. 25696528	DESIGNED: LSM	PROJ. ENGINEER: LSM		 111 S.W. Columbia, Suite 1500 Portland, Oregon 97201 (tel) 503-222-7200 (fax) 503-222-4292 www.urscorp.com	BRADFORD ISLAND CASCADE LOCKS, OREGON	RIVER OPERABLE UNIT FOREBAY AND REFERENCE AREA	DRAWING NUMBER: FIGURE 1-4	
		DRAWN BY: SB	APPROVED BY: MP					GIS FILE NUMBER: FIG 1-4	
		CHECKED BY: SB	DATE: JUNE 2011					SHEET:	REV.

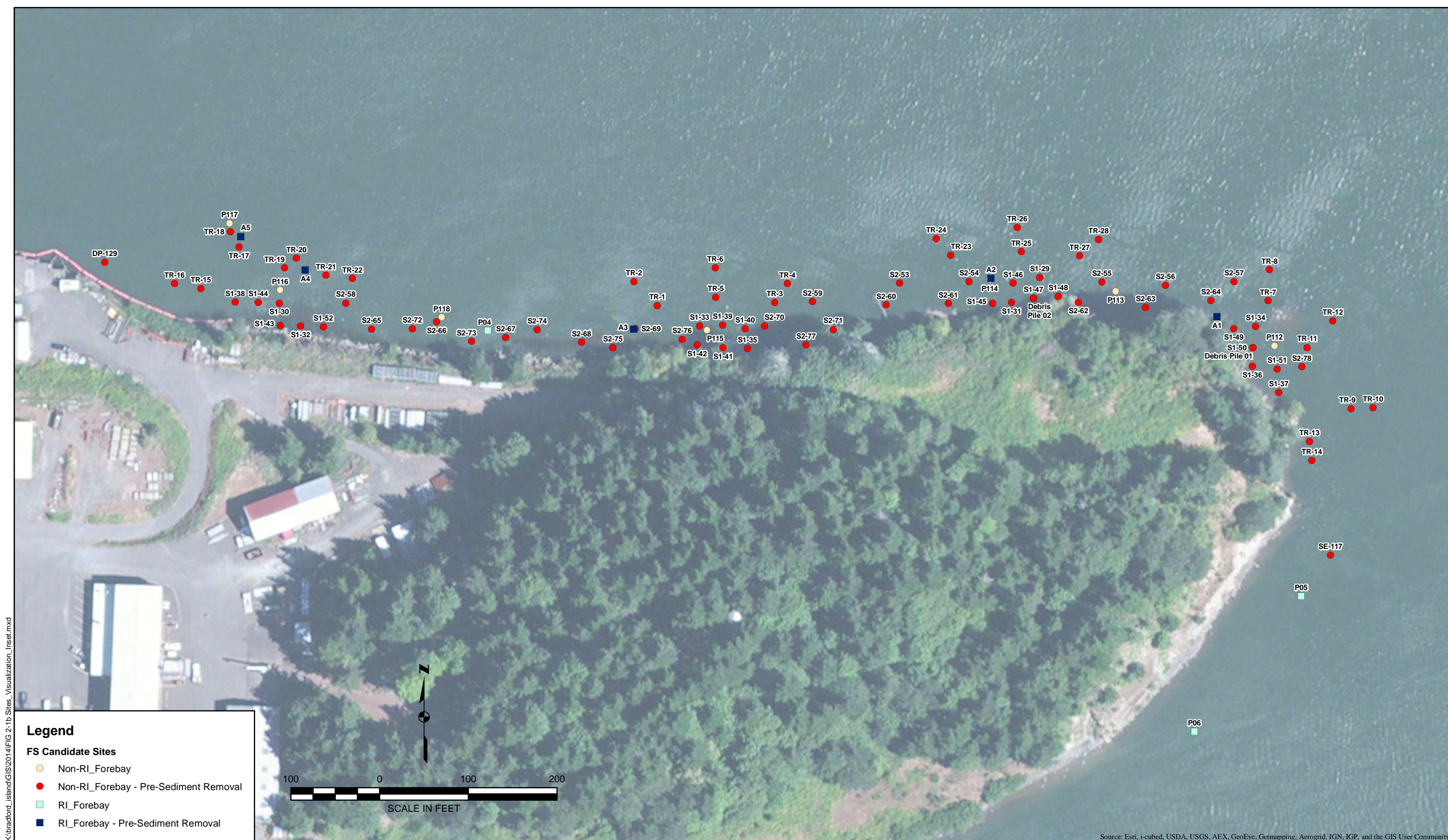


K:\bradford_island\GIS\2014\Data_Eval_TM\FIG 2-1a Sites_Visualization.mxd

Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

	JOB No. 25697943	DESIGNED: AH	PROJ. ENGINEER: DW		 111 S.W. Columbia, Suite 1500 Portland, Oregon 97201 (tel) 503-222-7200 (fax) 503-222-4292 www.urscorp.com	BRADFORD ISLAND CASCADE LOCKS, OREGON	RIVER OPERABLE UNIT SITE VISUALIZATION	DRAWING NUMBER: FIGURE 2-1a	
		DRAWN BY: SB	APPROVED BY: DW					GIS FILE NUMBER: FIG 2-1a	
		CHECKED BY: HP	DATE: JUNE 2014					SHEET:	REV.

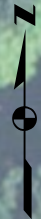
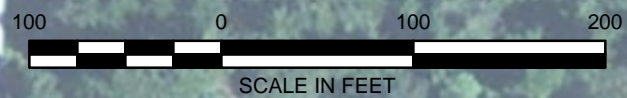
K:\bradford_island\GIS\2014\FIG 2-1b Sites_Visualization_Inset.mxd



Legend

FS Candidate Sites

- Non-RI_Forebay
- Non-RI_Forebay - Pre-Sediment Removal
- RI_Forebay
- RI_Forebay - Pre-Sediment Removal



Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community


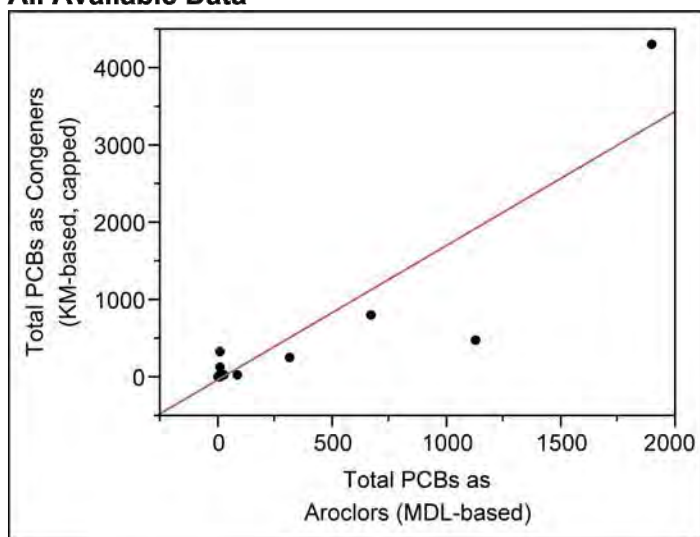
	JOB No. 25697943	DESIGNED: AH	PROJ. ENGINEER: DW			BRADFORD ISLAND	RIVER OPERABLE UNIT		DRAWING NUMBER: FIGURE 2-1b	
		DRAWN BY: SB	APPROVED BY: DW			CASCADE LOCKS, OREGON	SITE VISUALIZATION - INSET		GIS FILE NUMBER: FIG 2-1b	
		CHECKED BY: HP	DATE: JUNE 2014		111 S.W. Columbia, Suite 1500 Portland, Oregon 97201 (tel) 503-222-7200 (fax) 503-222-4292 www.urscorp.com				SHEET:	REV.

Figure 2-2a. Linear Regression Model Between Total PCB as Congeners and Total PCB as Aroclors, Using All Available Data

All Available Data



— Linear Fit

Linear Fit

Total PCBs as Congeners (KM-based, capped)
= -24.75832 + 1.7387777*Total PCBs as Aroclors (MDL-based)

Summary of Fit

RSquare	0.812268
RSquare Adj	0.808096
Root Mean Square Error	279.9606
Mean of Response	135.9525
Observations (or Sum Wgts)	47

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	15260468	15260468	194.7036
Error	45	3527008	78377.963	Prob > F
C. Total	46	18787477		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	-24.75832	42.42958	-0.58	0.5625
Total PCBs as Aroclors (MDL-based)	1.7387777	0.124611	13.95	<.0001*

**LINEAR REGRESSION MODEL BETWEEN TOTAL PCB AS CONGENERS AND
TOTAL PCB AS AROCLORS, USING ALL AVAILABLE DATA**



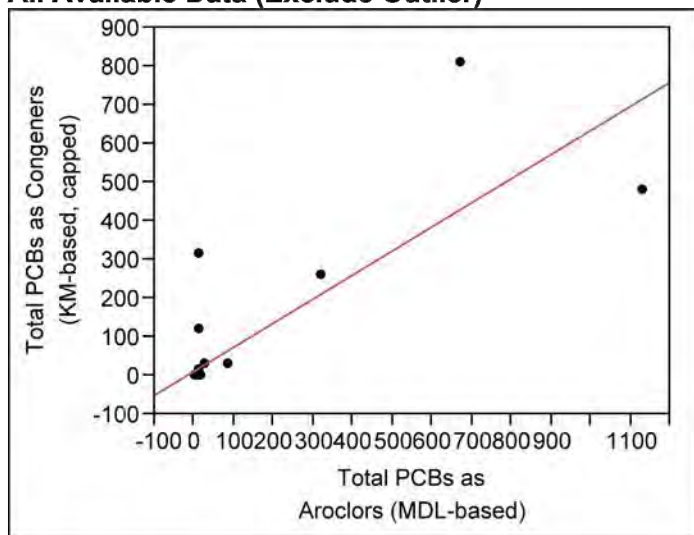
JUNE 2014
25697943

BRADFORD ISLAND
CASCADE LOCKS, OREGON

FIGURE 2-2a

Figure 2-2b. Linear Regression Model Between Total PCB as Congeners and Total PCB as Aroclors, Using All Available Data

All Available Data (Exclude Outlier)



— Linear Fit

Linear Fit

Total PCBs as Congeners (KM-based, capped)
= 12.086342 + 0.6227397*Total PCBs as Aroclors (MDL-based)

Summary of Fit

RSquare	0.682617
RSquare Adj	0.675403
Root Mean Square Error	83.6911
Mean of Response	45.17399
Observations (or Sum Wgts)	46

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	662832.90	662833	94.6336
Error	44	308184.81	7004	
C. Total	45	971017.71		

Prob > F
<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	12.086342	12.79976	0.94	0.3502
Total PCBs as Aroclors (MDL-based)	0.6227397	0.064015	9.73	<.0001*

**LINEAR REGRESSION MODEL BETWEEN TOTAL PCB AS CONGENERS AND
TOTAL PCB AS AROCLORS, USING ALL AVAILABLE DATA**



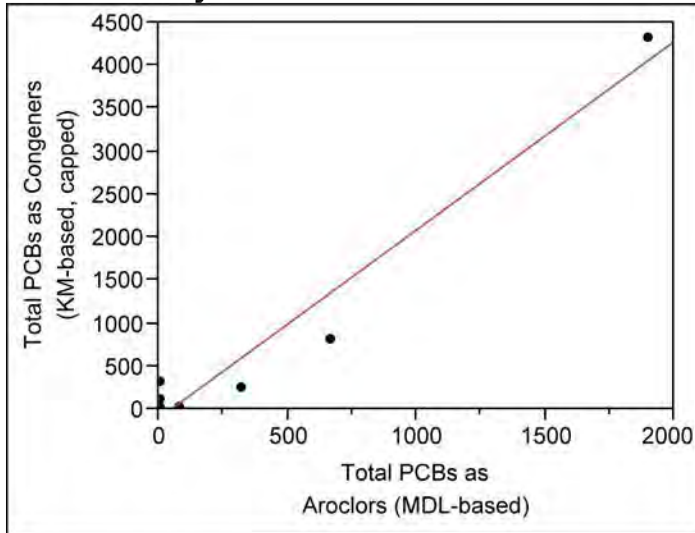
JUNE 2014
25697943

BRADFORD ISLAND
CASCADE LOCKS, OREGON

FIGURE 2-2b

Figure 2-3a Linear Regression Model Between Total PCB as Congeners and Total PCB as Aroclors, Using 2011 Data Only

2011 Data Only



— Linear Fit

Linear Fit

Total PCBs as Congeners (KM-based, capped)
= -105.7988 + 2.1927236*Total PCBs as Aroclors (MDL-based)

Summary of Fit

RSquare	0.952018
RSquare Adj	0.942422
Root Mean Square Error	373.3737
Mean of Response	836.4458
Observations (or Sum Wgts)	7

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	13830114	13830114	99.2061
Error	5	697039	139407.89	
C. Total	6	14527153		

Prob > F
0.0002*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	-105.7988	169.8962	-0.62	0.5608
Total PCBs as Aroclors (MDL-based)	2.1927236	0.220148	9.96	0.0002*

**LINEAR REGRESSION MODEL BETWEEN TOTAL PCB AS CONGENERS AND
TOTAL PCB AS AROCLORS, USING 2011 DATA ONLY**



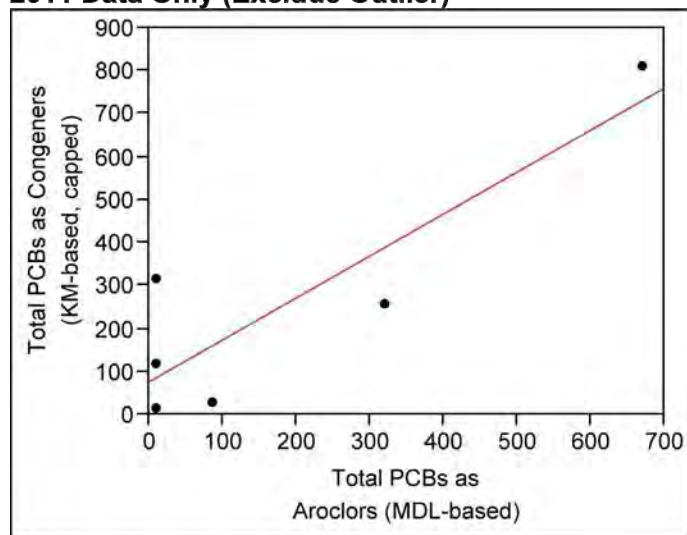
JUNE 2014
25697943

BRADFORD ISLAND
CASCADE LOCKS, OREGON

FIGURE 2-3a

Figure 2-3b. Linear Regression Model Between Total PCB as Congeners and Total PCB as Aroclors, Using 2011 Data Only

2011 Data Only (Exclude Outlier)



— Linear Fit

Linear Fit

Total PCBs as Congeners (KM-based, capped)
= 76.97646 + 0.9760832*Total PCBs as Aroclors (MDL-based)

Summary of Fit

RSquare	0.773848
RSquare Adj	0.71731
Root Mean Square Error	157.0699
Mean of Response	257.2265
Observations (or Sum Wgts)	6

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	337676.53	337677	13.6872
Error	4	98683.82	24671	
C. Total	5	436360.36		

Prob > F
0.0208*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	76.97646	80.5331	0.96	0.3933
Total PCBs as Aroclors (MDL-based)	0.9760832	0.263833	3.70	0.0208*

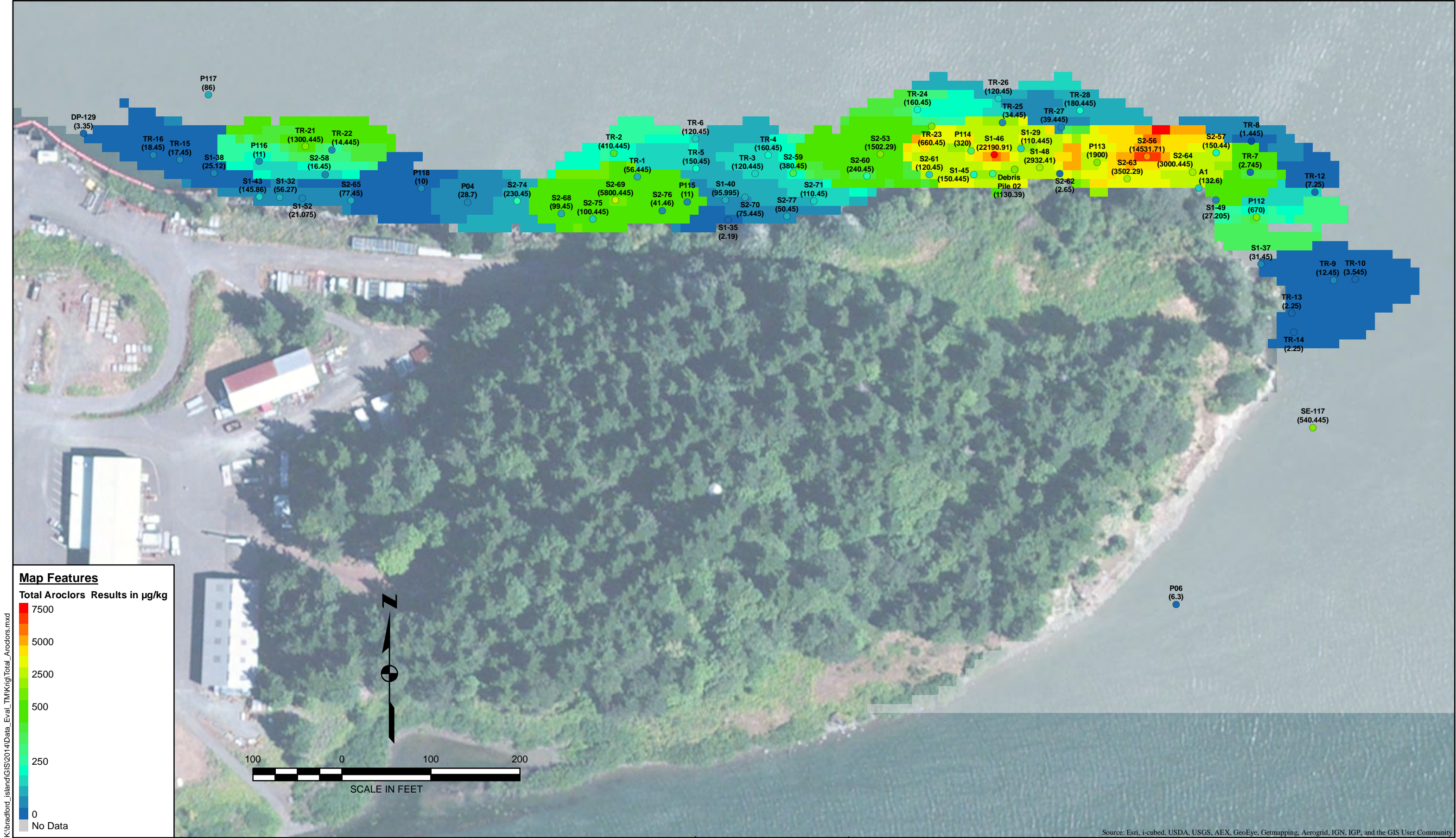
**LINEAR REGRESSION MODEL BETWEEN TOTAL PCB AS CONGENERS AND
TOTAL PCB AS AROCLORS, USING 2011 DATA ONLY**



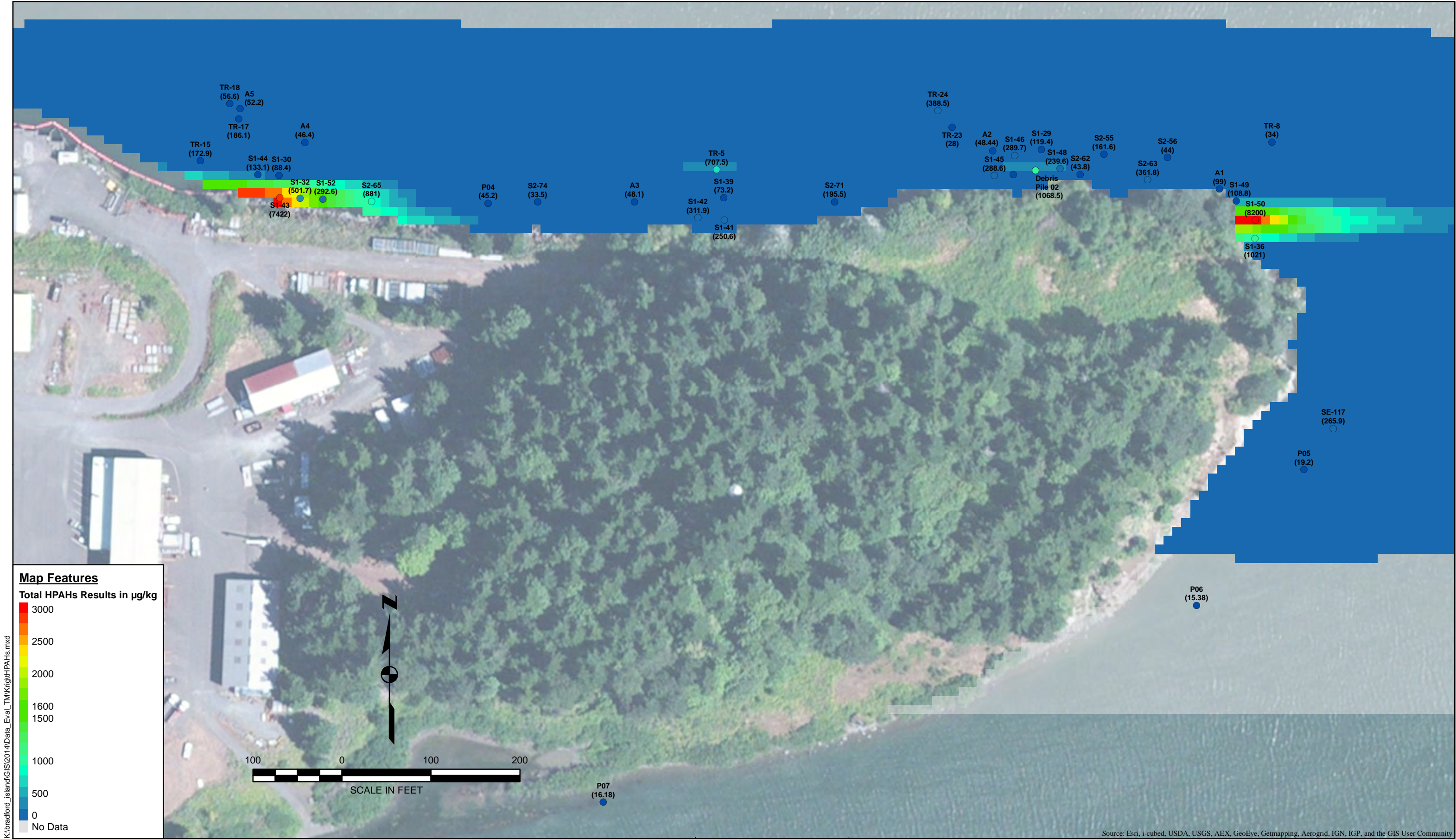
JUNE 2014
25697943

BRADFORD ISLAND
CASCADE LOCKS, OREGON

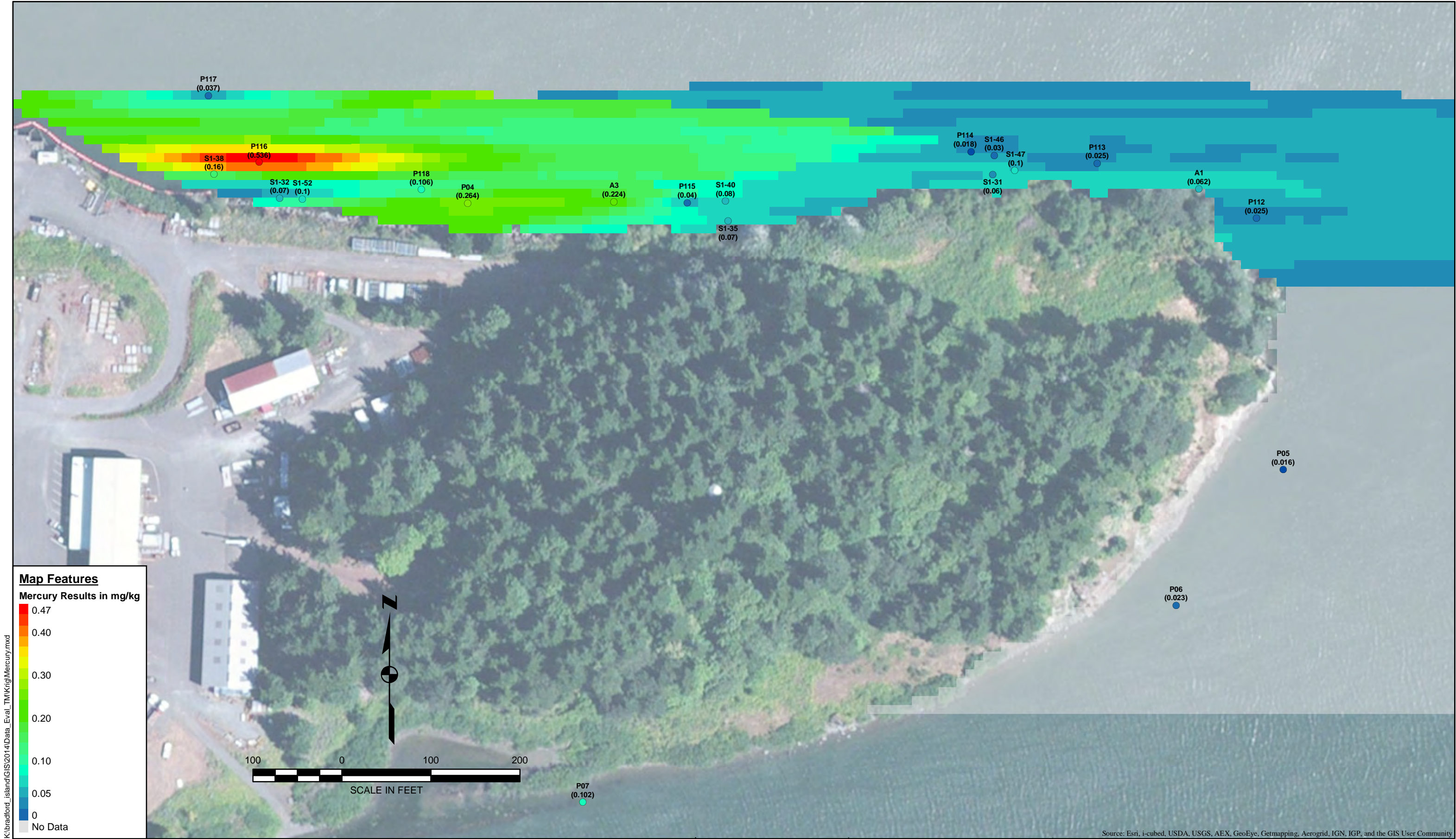
FIGURE 2-3b



	JOB No. 25697943	DESIGNED: AH	PROJ. ENGINEER: DW		BRADFORD ISLAND	RIVER OPERABLE UNIT	DRAWING NUMBER: FIGURE 3-1	
		DRAWN BY: SB	APPROVED BY: DW				GIS FILE NUMBER: FIG 3-1	
		CHECKED BY: HP	DATE: JUNE 2014				SHEET:	REV.



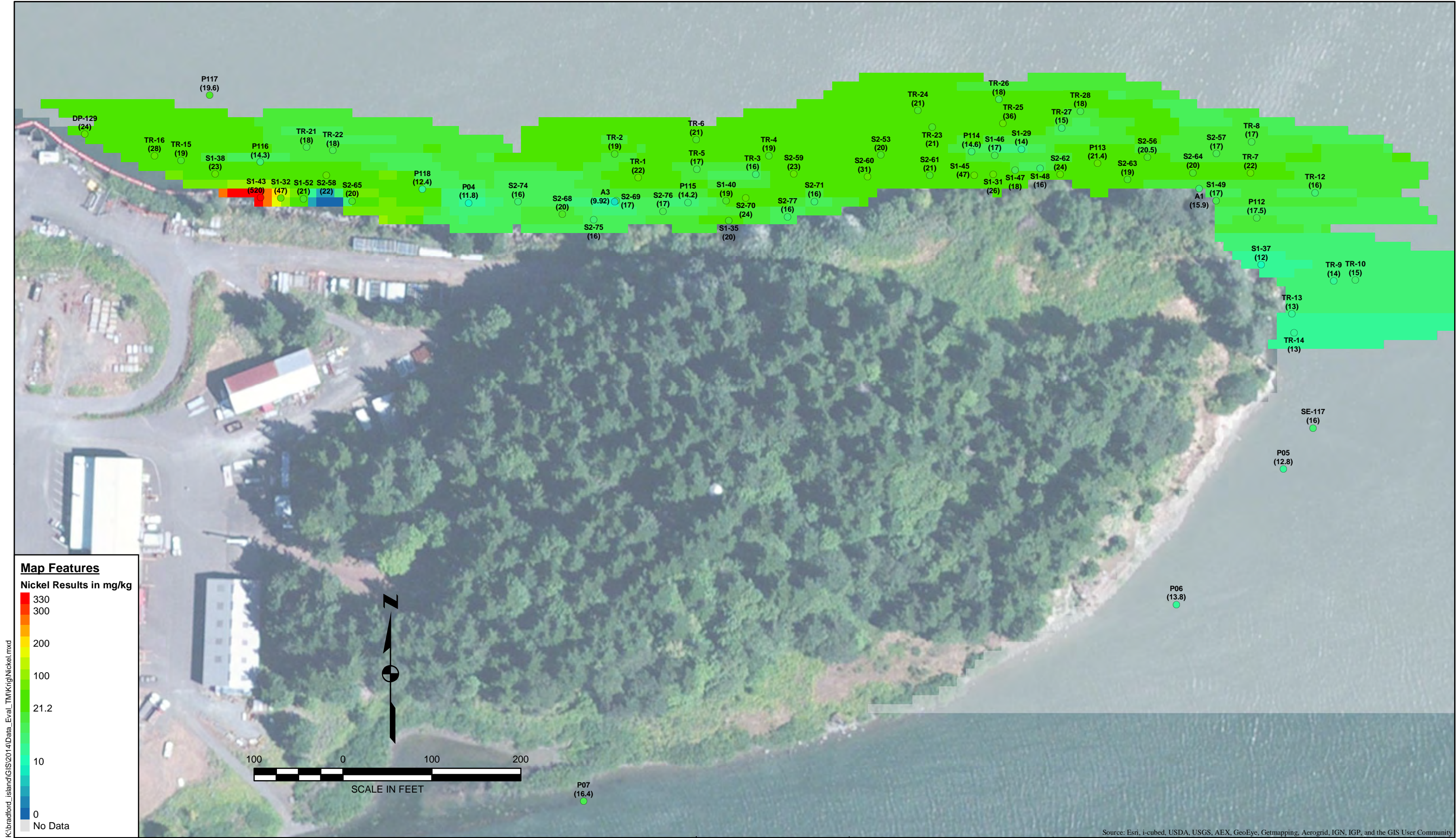
	JOB No. 25697943	DESIGNED: AH	PROJ. ENGINEER: DW		URS 111 S.W. Columbia, Suite 1500 Portland, Oregon 97201 (tel) 503-222-7200 (fax) 503-222-4292 www.urscorp.com	BRADFORD ISLAND CASCADE LOCKS, OREGON	RIVER OPERABLE UNIT TOTAL HPAHs CONCENTRATIONS	DRAWING NUMBER: FIGURE 3-2	
		DRAWN BY: SB	APPROVED BY: DW					GIS FILE NUMBER: FIG 3-2	
		CHECKED BY: HP	DATE: JUNE 2014					SHEET:	REV.



K:\bradford_island\GIS\2014\Data_Eval_TMW\King\Mercury.mxd

Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

	JOB No. 25697943	DESIGNED: AH	PROJ. ENGINEER: DW		BRADFORD ISLAND	RIVER OPERABLE UNIT	DRAWING NUMBER: FIGURE 3-4	
		DRAWN BY: SB	APPROVED BY: DW				GIS FILE NUMBER: FIG 3-4	
		CHECKED BY: HP	DATE: JUNE 2014				SHEET:	REV.
				111 S.W. Columbia, Suite 1500 Portland, Oregon 97201 (tel) 503-222-7200 (fax) 503-222-4292 www.urscorp.com	CASCADE LOCKS, OREGON	MERCURY CONCENTRATIONS		



K:\bradford_island\GIS\2014Data_Eval_TM\King\Nickel.mxd

Map Features

Nickel Results in mg/kg

330

300

200

100


21.2

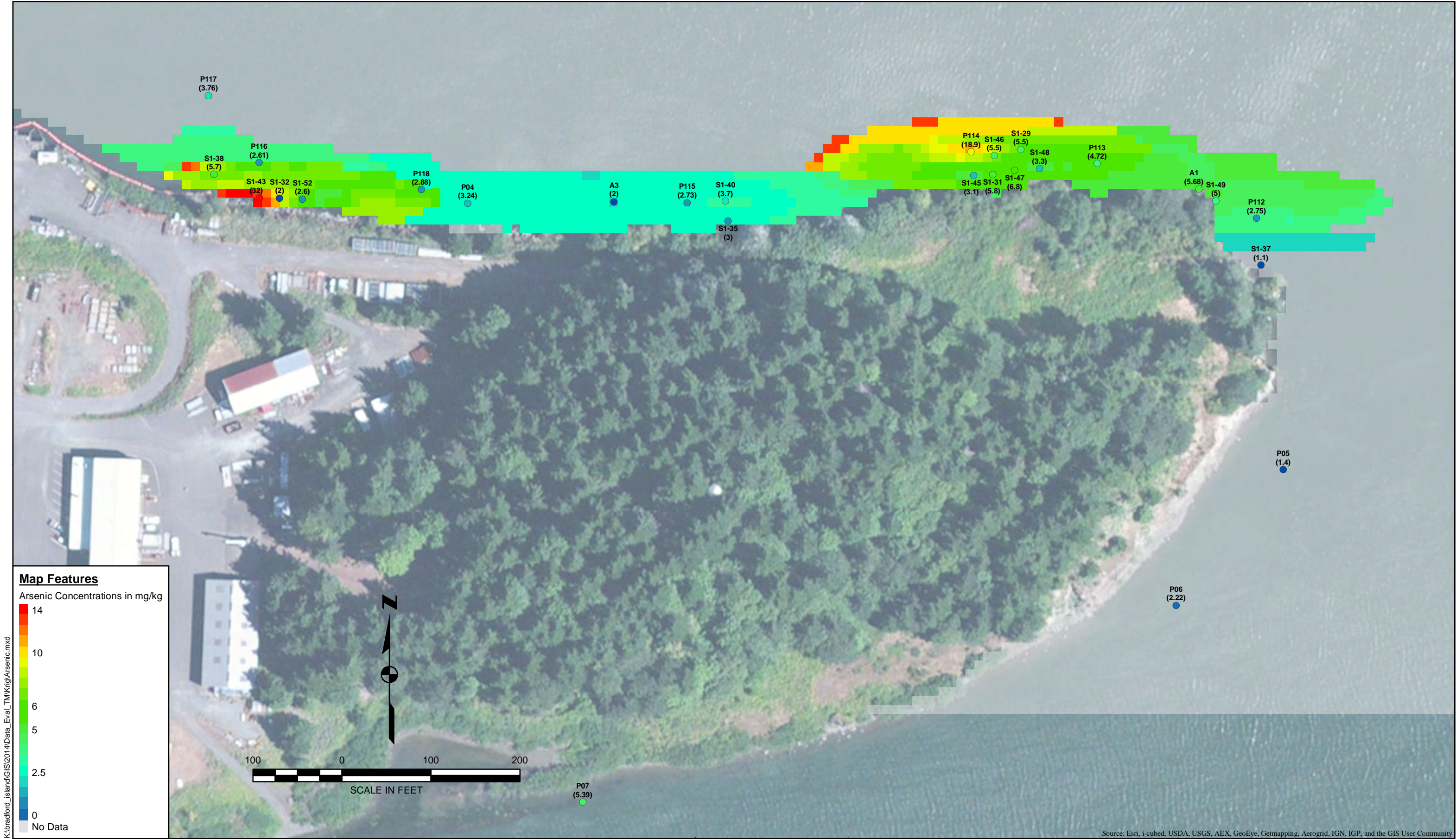
10

0

No Data

Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

	JOB No. 25697943	DESIGNED: AH	PROJ. ENGINEER: DW	 111 S.W. Columbia, Suite 1500 Portland, Oregon 97201 (tel) 503-222-7200 (fax) 503-222-4292 www.urscorp.com	BRADFORD ISLAND CASCADE LOCKS, OREGON	RIVER OPERABLE UNIT NICKEL CONCENTRATIONS	DRAWING NUMBER: FIGURE 3-5	
		DRAWN BY: SB	APPROVED BY: DW				GIS FILE NUMBER: FIG 3-5	
		CHECKED BY: HP	DATE: JUNE 2014				SHEET:	REV.



K:\bradford_island\GIS\2014Data_Eval_TMW\King\Arsenic.mxd

Map Features

Arsenic Concentrations in mg/kg

14

10

6

5

2.5

0

No Data

Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

	JOB No. 25697943	DESIGNED: AH	PROJ. ENGINEER: DW	<div>URS</div> <div>111 S.W. Columbia, Suite 1500 Portland, Oregon 97201 (tel) 503-222-7200 (fax) 503-222-4292 www.urscorp.com</div>	BRADFORD ISLAND	RIVER OPERABLE UNIT	DRAWING NUMBER: FIGURE 3-3	
		DRAWN BY: SB	APPROVED BY: DW				GIS FILE NUMBER: FIG 3-3	
		CHECKED BY: HP	DATE: JUNE 2014				SHEET:	REV.